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Higher Education in Innovation Ecosystems

Edited by
Yuzhuo Cai, Jinyuan Ma and Qiongqiong Chen

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Preface to "Higher Education in Innovation Ecosystems"

Societal changes are leading to the demand for broader roles for universities, and this also calls for, and leads to, substantial changes within the internal fabric of the university. Significant innovations in both society and universities necessitate a renewed understanding of the social missions of higher education in society. Among both researchers and policymakers, universities have been considered increasingly important for regional economic growth and innovation, sustainable development, and global partnership building. We believe that all these dimensions of universities' societal engagement, requiring various innovations in higher education, can be integrated into the framework of innovation ecosystems. This has motivated our editors to organize this Special Issue in order to tackle a new research agenda: higher education in innovation ecosystems.

Dealing with interactions between innovations in higher education and innovation ecosystems in research is by no means easy. While innovations in higher education and innovation ecosystems, as buzzwords, have captured the imagination of policymakers, both are loosely used, without a consensus on their actual meanings. By collecting 16 research papers which contribute to discussions on the theme of the Special Issue, from theoretical, methodological and empirical perspectives, we advance both conceptualization of higher education in innovation ecosystems and empirical research on the topic.

The 16 articles, contributed by 44 authors from 10 countries, can generally be divided into four categories: 1) new demands for universities arising from the transformation in the society towards innovation ecosystems, 2) transformations within higher education responding to emerging societal demands, 3) dynamics of interaction of universities with other innovation actors in transnational contexts, and 4) academic and student mobility for higher education innovation.

As outcomes of synthesizing the collected articles in the Special Issue, we re-defined the concept of innovation ecosystem and identified three roles of universities in innovation ecosystems in the Special Issue Editorial. These constitute an overarching framework that facilitates readers to comprehend the individual articles in the Special Issue and find synergy among them.

We hope that our Special Issue will inspire and encourage more scholars to join this research area. Although the Special Issue primarily targets academic readers, it is also relevant for policy and managerial audiences.

In closing, we would like to thank the editorial team of the *Sustainability* journal for inviting us to be guest editors for the Special Issue. We thank all the authors and reviewers for their valuable contributions. We also acknowledge the financial support for the organisation and publication of the Special Issue from the project National Education Sciences "Thirteenth Five-Year Plan" of China, under grant number BIA190166, and from the project of Shenzhen Social Sciences Association, under grant number SZ2018A009.

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Editorial

Higher Education in Innovation Ecosystems

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Abstract: While higher education has been considered as both an 'engine' for innovation and a 'catalyst' for sustainability development, the integration of both the 'innovation engine' and 'sustainability catalyst' roles is best reflected in higher education's engagement in innovation ecosystems—the theme of this special issue, including 16 articles dealing with the topic from various perspectives. In this editorial, we outline an overarching framework about the relations between higher education and innovation ecosystem. When elaborating the framework, we provide a new definition of innovation ecosystem and identify three roles of university in innovation ecosystems, based on synthesizing relevant literature. The framework could facilitate readers to comprehend each of the collected articles and find synergy among them.

Keywords: higher education; university; sustainability; innovation ecosystem; third mission; knowledge-based society; global innovation networks

1. Introduction

The policy and research discussions on sustainable development often deal with two intricately interrelated transformations, namely societal transformation (or innovation in the society) and university transformation (or innovation in the university) [1]. Contemporary societal changes have been recently described as a transformation from knowledge society 1.0 to knowledge society 2.0 [2] that fosters an innovation ecosystem [3]. The core underlying the knowledge society 2.0 is that knowledge is not simply distinguished between tacit and codified type as in knowledge economy 1.0 but context-dependent. Consequently, learning and knowledge production is now taking place in the context of social interactions rather than in organizational contexts [4,5]. Its implication on an innovation ecosystem is that the core elements in the system are increasingly interdependent and bind together by co-evolution/co-creation mechanisms, comparable to complicated relations among organisms in a bio-system [6].

In the innovation ecosystem, a university is not merely serving as a primary engine for economic growth through knowledge transfer [7], but is required to be more socially responsible [8]. As put by UNESCO's Chief of Higher Education Sector, Peter J. Wells, "Perhaps never before in recent history has the role of higher education been so intricately tied to the economic, social and environmental fabric of the modern world" [9]. The societal changes demanding broader roles of universities also calls for, and leads to, substantial changes within the internal fabric of the university. The innovations in both the society and universities call for our renewed understanding of higher education in society, which becomes a new research agenda in studies on innovation in higher education [1].

This special issue is a timely response to the new research agenda with 16 selected articles, making theoretical, methodological, or empirical contributions to the emerging research agenda on higher education in innovation ecosystems. While the special issue primarily targets academic readers, it is also of relevance to policy and managerial audiences. To help readers better understand each article and find synergy among the articles, we provide here an overarching framework, in which some key concepts are defined and the changing relations between higher education and innovation ecosystem are elaborated.

2. Conceptualizing Innovation Ecosystem

The notion of innovation ecosystem has been evolved from the concept of business ecosystem, which was originally proposed by Moore in 1993 [10], who proposed a perspective of seeing a company as part of a business ecosystem instead of a single industry. The ecosystem crosses a variety of industries; "In a business ecosystem, companies co-evolve capabilities around a new innovation: they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations" (p. 76) [10]. The term business ecosystem has often been treated exchangeable to innovation ecosystem [11–13]. Besides, another similar concept to business ecosystem is knowledge ecosystem [14]. Valkokari [15] identifies the differences between the three kinds of ecosystems: business ecosystem focuses on creating customer value; knowledge ecosystem focuses on generating new knowledge and technologies; innovation ecosystem integrates exploration (knowledge) and exploitation (business) ecosystems.

However, such distinction does not clearly distinguish innovation ecosystem from the innovation system [16–19], which consists of complex functions and interactions among various organizational actors, involved in processes of both knowledge exploration and knowledge exploitation, and their institutional contexts, in the forms of governmental policies and social norms [20]. As noted by Oh, Phillips, Park and Lee [6] there are, "few academic articles using 'innovation ecosystem' in a manner that would distinguish an innovation ecosystem from an innovation system" (p. 2).

What makes the concept innovation ecosystem distinct to either business ecosystem or innovation system is value co-creation [3,21]. "The concept of value co-creation is basically associated with a business strategy focusing on interactive relationships between producers and consumers" (p. 5247) [21]. The business ecosystem is primarily concerned with value capture and innovation ecosystem is more related to value co-creation [3]. "Ecosystems can't be deliberately established as system-like organizations . . . Ecosystems are tailored to interactive co-creation of values, while systems are not" (p. 5248) [21]. Carayannis, et al. [22] take a broad perspective to understand the value co-creation, that is not merely between producers and customers but takes places among multiple actors in the framework of Quadruple Helix.

Synthesizing the discussions on the new features of innovation ecosystem, Cai, et al. [23] claim that "what is new in the innovation ecosystem is its ecological aspect, characterized by the interdependency among different collaborative actors and the co-evolution/co-creation that binds them together over time, along with the sustainable development dimension" (p. 6) [23]. They also refer to "co-innovation" [24] networks when understanding innovation ecosystem. The concept of co-innovation includes "collaboration, coordination, co-creation, convergence, and complementary" (p. 361) [25], and it can be understood as "the dynamically intertwined processes of co-opetition, co-evolution, and co-specialization within and across regional and sectoral innovation ecosystems" (p. 153) [22]. When understanding the mechanisms in the innovation ecosystems, Cai et al. call for integrating the insights of Helix models of innovation [23], including the Triple Helix Model [7,26], Quadruple Helix Model [27], and Triple Helix of sustainability [28].

In such light, we define innovation ecosystem as co-innovation networks, in which actors from organizations concerned with the functions of knowledge production, wealth creation and norm control interact with each other in forming co-evolution and interdependent relations (both direct or indirect) in cross-geographical contexts, and, through which new ideas and approaches from various internal and external sources are integrated into a platform to generate shared values for the sustainable transformation of the society. Compared to most commonly cited definitions of innovation ecosystem [3,29], our definition highlights three new aspects of interactions in co-innovation networks, namely *cross-sectoral*, *transnational* and *indirect*, drawing insights from the literature of innovation, geography, and biology studies.

First, the actors in an innovation ecosystem are from different sectors. Such a view is clearly reflected in the conceptualization of both Triple Helix [30] and Quadruple Helix [27] models of innovation. While most studies on innovation ecosystems mainly focus on companies and industrial clusters [3], it should be noted that in the knowledge-based society, innovation is fostered by the interactions of organizations with multiple functions, such as wealth generation, knowledge production, and normative control [7,26]. When elucidating the Quadruple Helix model, Carayannis and Campbell [27] consider that in an innovation ecosystem, "people, culture and technology – forming the essential 'Mode 3 Innovation Ecosystem' building block meet and interact to catalyze creativity, trigger invention and accelerate innovation across scientific and technological disciplines, public and private sectors (government, university, industry and non-governmental knowledge production, utilization and renewal entities) and in a top-down, policy-driven as well as bottom-up, entrepreneurship-empowered fashion" (pp. 202–203).

Second, the actors from different geographical locations can be interlinked in an innovation ecosystem. This has been clearly noted by Sotarauta, et al. [31] when identifying key features of innovation ecosystems, using the label "multi-locational", meaning that knowledge flows and innovation processes take place in multiple geographical locations (pp. 31–32). The transnational dimension of innovation ecosystems has also been reflected in innovation research [32–36] and geography studies [37], both addressing the direction of innovation systems becoming global or transnational.

Third, when studying the relations in the innovation ecosystem, it is crucial to pay attention to indirect or unobvious relations as suggested by Cai, Ferrer and Lastra [23]. This also corroborates the approaches to the ecosystem in the biological world. As Krivtsov [38] noted, ecological research on ecosystems had mainly concentrated on investigations of direct relationships, whilst examining indirect relations and interdependences (especially the less obvious relations) between organisms was a recent phenomenon. The "organic nature" of innovation ecosystem means that the system evolves through its components' continuous adaptation to changing situations [31].

In spite of our attempt to providing a definition of innovation ecosystem, we admit that any definitions are not sufficient to fully understand the system. Rather, a conceptual or theoretical framework for elucidating the nature and dynamics of innovation ecosystems is needed. As argued by Oh, Phillips, Park and Lee [6], the concept of innovation ecosystem is a high level of abstraction and loosely used; it is often understood as a metaphor rather than a theory or framework. Thus, Ritala and Almpanopoulou [39] call for future research to improve the conceptual, theoretical and empirical rigor of the notion of innovation ecosystem. One barrier to advancing the conceptualization of innovation ecosystem lies in the narrow focus of existing approaches, tending to assemble innovation ecosystem according to the components in a natural ecosystem [40]. Such an approach leads to some seemingly unresolvable paradoxes, such as the deliberate design of innovation ecosystems not actually resembling ecosystems in nature [6,41].

To develop a rigorous conceptualization of innovation ecosystem is a systematic project requiring collaboration among scholars in different fields of research, with multiple disciplinary insights and through solid empirical investigations. For instance, in both higher education and innovation studies, there is a tendency in bringing emerging factors and complex links in the innovation ecosystem into analysis foci [42,43]. This Special Issue is aimed to contribute to a potential analytical framework of innovation ecosystem by focusing on the changing roles of universities in innovation ecosystems and related transformations within higher education.

3. Changing Roles of Higher Education in Innovation Ecosystems

While our society is becoming increasingly knowledge-based, the prominent role of universities in societal engagement, especially in the regional context, is becoming a shared understanding [44,45]. Most concepts in innovation studies, such as innovation system [19], Triple Helix model [30], and open innovation [46], originated in the context of developing knowledge-based society, stress new kinds of relations between universities and economic development. Etzkowitz [7] clearly states that the university has transformed from a secondary to a primary institution for economic growth in the knowledge-based society. Such "innovation engine" role of higher education emphasizes the long-term economic effects of the university's societal engagement, such as improving the quality of local labor, transferring technology to the industry, and enhancing the attractiveness of the local environment for entrepreneurs [20]. This is in contrast to the short-term multiplier effects mainly through universities' employing local workers, occupying a large area of land and their demand for local services [47].

As we are entering the era of innovation ecosystem with distinct features such as sustainable societal transformation, co-innovation and transnational knowledge exchange, there are also new societal demands for the higher education. What are the changing roles of higher education in the context of innovation ecosystems? This is a new research agenda. Nevertheless, some recent studies may shed light on it. For instance, a recent report published by the European University Association (EUA) specified four roles of universities in regional innovation systems as follows [42]: "Education: providing human 'capital' for innovation", "Research: knowledge (co-)production for private and public value creation", "Knowledge exchange for innovation systems: From technology transfer to multi-actor co-creation" and "Strategic transformation: embedding innovation" (pp. 22–47). Continuing from Cai's call for the concept of socially responsible entrepreneurial university [48], Cai, Ferrer and Lastra [23] suggest three roles of university in transnational university-industry co-innovation networks in innovation ecosystems, namely transnational technology transfer, trust-building between the university and industrial actors, and fostering changes of social norms needed in building innovation ecosystems. While the EUA's report is focusing on university's regional engagement [42], Cai, Ferrer and Lastra [23] understand the role of universities in a global context. However, Cai, Ferrer and Lastra [23] do not discuss the roles in details. Here, we will further elaborate on the three roles of university in innovation ecosystems proposed by Cai, Ferrer and Lastra [23] by synthesizing relevant literature.

First, the role of university is changing from being a central player in technology transfer to being an anchor organization in knowledge exchange. Technology transfer is typically defined as "the process of moving technology from an institution of the science base (e.g., a higher education institution) to an industrial organization, which ... commercializes the technology through the implementation of new processes, the development and launch of new products or the facilitation of a successful and innovative organizational change" (p. 613) [49]. While technology transfer is one direction move of the knowledge from the academy to the industry, "knowledge exchange", as described by Moreton [50], is bi-directional. "[U]niversity–industry interaction does not involve only transferring knowledge from the former to the latter; it also helps academics to develop interesting research questions, conduct better research and provide improved understanding of research applications in industry" (p. 109) [51]. Knowledge exchange entails both aspects of collective learning between organizations from different sectors and (conventional) technology transfer [5]. Such bi-directional nature of knowledge exchange is the key to value co-creation. Here, the university is not merely a knowledge creator but also an enabler of value co-creation.

Second, the university is taking a new role for trust-building between actors in innovation ecosystems. The interactions among actors in an innovation ecosystem can be understood as social relations and the knowledge exchange is an outcome of social relations. Social relations/interactions can be explained by two theories, namely social exchange theory [52] and social network theory [53], which are supplementing to each other [54]. From both perspectives, trust is considered a key factor to successful knowledge exchange and co-innovation.

According to social exchange theory, social interactions are shaped by the reciprocal exchange of rewards (or more rewards than costs) [52]. When Muthusamy and White [5] apply social exchange theory to analyze social interactions in the process of collective learning and knowledge transfer, they posit that "[s]ince there is no way to assure an equivalent return for a favor, social exchange requires trusting others to discharge their obligations" (p. 418). As such, successful interactions between actors in an innovation ecosystem relies on trust between the collaborators [55].

From the perspective of social network theory, innovation requires a combination of both strong and weak ties [56–58]. "Weak ties aid exploration (the generation of new ideas), whereas strong ties aid exploitation (the implementation of new ideas)" (p. 212) [59]. The creation and diffusion of innovation are mostly attributed to weak ties [60]. While the most useful knowledge/ideas would come from weak ties, one challenge is that the level of trust between actors connected by weak ties might be low [61]. Due to its own trustworthy status in the society and its close links to actors across sectors via alumina and research partnership, university can be a unique social trust builder [23,62] for co-innovation networks.

Third, the university is not merely an entrepreneurial university but also an institutional entrepreneur in the innovation ecosystem [63]. Institutional entrepreneurs are those organizational or individual actors who not only initiate diverse changes in the institutional environment but also actively participate in the implementation of such changes [64]. "Institutions can be generally understood as social orders [65], social rules [66], or taken-for-granted norms and beliefs [67], which are seen by actors as natural, rightful, expected, and legitimate" (p. 462) [68]. Audretsch [69] asserts that "while the entrepreneurial university was a response to generating technology transfer and knowledge-based start-ups, the role of the university in the entrepreneurial society has broadened to focus on enhancing entrepreneurship capital and facilitating behavior to prosper in an entrepreneurial society" (p. 312). Both "enhancing entrepreneurship" and "facilitating behavior" requires changes in the institutional environment. The process of fostering institutional changes can be understood as social entrepreneurship [70], which is "an innovative approach to achieve social mission" (p. 744) [71], being considered as a key to an innovation system [72].

The three emerging roles all indicate that universities are becoming the catalyst for sustainable development in innovation ecosystems. Knowledge exchange is crucial for suitability [73]; trust is the foundation of the sustainable networks [74]; social entrepreneurship is indispensable to sustainable social change [75].

The articles collected in this Special Issue, to varying extents, reflect the changing roles of higher education in innovation ecosystems. Meanwhile, they also report transformations within higher education and universities' responses to both external and internal transformations. When addressing these issues, the studies make both theoretical and methodological contributions in the research on higher education in innovation ecosystems.

4. The Articles in the Special Issue

The 16 articles collected in the Special Issue can be generally put in four categories: (1) New demands for universities arising from the transformation in the society towards innovation ecosystems, (2) Transformations within higher education responding to emerging societal demands, (3) Dynamics of the interaction of university with other innovation actors in a transnational context, (4) Academic and student mobility for higher education innovation. Next, we will briefly introduce each article in the Special Issue in the four categories respectively.

4.1. New Demands for Universities Arising from the Transformation in the Society towards Innovation Ecosystems

The article by Ye and Wang, "Exploring the Triple Helix Synergy in Chinese National System of Innovation" [76], creates a simulation equation based on non-linear complex systems theory to offer steps towards a possible solution to estimate the Triple Helix synergy in China. The research considers that the domestic academic knowledge capacity is the order variable which is dominant in the Triple Helix evolution in China, and the industry plays as the major driving force in China's national innovation system. It also suggests that policies with strong incentives are effective in enhancing the absorptive capacity of industry and knowledge transfer of universities.

The green economy is regarded as an important tool for sustainable development. However, the role of higher education in a green economy is seldom discussed in the literature. The article, "An Empirical Study of the Role of Higher Education in Building a Green Economy" by Gao, Ding, Chen and Min [77] contributes to filling this gap by proposing a interpretation of the influencing mechanism of higher education on the green economy. They find that higher education plays a significant role in building a green economy, and green gross domestic product (GDP) is more responsive to changes in higher education than the traditional GDP.

Considering the increasing trends of higher education involvement in social innovation practices, Kumari, Richa, Kwon, Lee and Choi examine the role of Higher Educational Institutions (HEIs) in promoting, creating, and sustaining social innovation, in their article "Co-Creation for Social Innovation in the Ecosystem Context: The Role of Higher Educational Institutions" [78]. They develop a theoretical understanding of the "co-creation for social innovation" concept and to understand the functions and activities of HEIs that can contribute to this process. They argue that different activities such as mutual learning and knowledge diffusion using a transdisciplinary approach, technology-based learning and collaboration, and relational transformation are key enablers that can promote social innovation.

In the context of knowledge economy, universities are increasingly paying more attention to developing academic entrepreneurship. In the article, "Developing the Entrepreneurial University: Factors of Influence", Bezanilla, García-Olalla, Paños-Castro and Arruti analyze the relationships between the relevant factors that contribute to the development of the entrepreneurial university in Spain through a quantitative inquiry. They find that universities' contextual factors have only minor influence on the development of entrepreneurial university. Factors, such as entrepreneurship funding, training in entrepreneurship for faculty staff, mission and strategy, support from the management team, training and research in entrepreneurship and extra-curricular training, are found as most influential. Their study helps universities to adopt measures that are better suited to promoting entrepreneurship [79].

In response to the new demands of external stakeholders such as knowledge-intensive enterprises, higher education institutions have to play the role of knowledge brokers in smart specialization. The study by Kangas and Aarrevaara [80], "Higher Education Institutions as Knowledge Brokers in Smart Specialisation", uses a case of European Commission's smart specialization project and collects data through 20 interviews; it finds out that higher education institutions' role as knowledge brokers can be legitimated from social networking, decision-making and cluster building as well as exchange programs.

4.2. Transformations within Higher Education Responding to Emerging Societal Demands

In the article, "Training Entrepreneurial Competencies with Open Innovation Paradigm in Higher Education" [81], Iglesias-Sánchez, Jambrino-Maldonado and de las Heras-Pedrosa use mixed methods combining a qualitative technique based on three focused groups of lecturers, students and entrepreneurs, with a regression analysis seeking connections between entrepreneurial intention and employability with entrepreneurial competences. The study identifies the following teaching methods effective for university students to improve entrepreneurial competencies required by future employers: hackathon, team building, role play, and practical cases with entrepreneurs.

The article by Portuguez Castro, Ross Scheede and Gómez Zermeño on "The Impact of Higher Education on Entrepreneurship and the Innovation Ecosystem: A Case Study in Mexico" [82], presents a case study of a Master of Science program to train Mexican students with entrepreneurial skills. Based on the survey data from the former students of this program, the study concludes that the training methods taken by the program are useful competencies for creating technology-based enterprises and can be emulated in Latin America.

The article by Wang, Yang, Cheng and Ni, "Postgraduate Education of Board Members and R&D Investment—Evidence from China" [83], reveals the correlation between firms' research and development (R&D) investment with the directors' postgraduate education experience. The research finds out that the percentage of directors with doctorates significantly increases the chance of investing R&D activities; in the second industry, the higher the proportion of postgraduate education degree holder as directors in a firm, the more expenditure the firm invests in R&D activities. Yet, there is no such association in the third industry. The findings are generated from taking descriptive statistics, ordinary least square (OLS) regression and instrumental variable (IV) estimation based on a sample of 1374 listed companies in China. This study enriches the innovation management theory, upper echelon theory, and human capital theory.

The complex demands from the society cause tensions in universities. To understand the tensions within universities from the perspective of sustainable development, Lattu and Cai introduce an analytical framework in their article "Tensions in the Sustainability of Higher Education—the Case of Finnish Universities" [84]. The analytical framework is based on the conceptualization of corporate sustainability and adjust it to the context of higher education by using Finnish universities as a testbed for analysis. The authors also identify six tensions relating to the sustainability of Finnish universities.

The article by Cruz-Amarán, Damaris, Maribel Guerrero, and Alma Delia Hernández-Ruiz [85], "Changing Times at Cuban Universities: Looking into the Transition towards a Social, Entrepreneurial and Innovative Organization", interprets a particular case of socialist higher education system in the process of entrepreneurial transition over the past two decades. The study proposes an analytical model by integrating the theoretical bases of entrepreneurial universities, social entrepreneurship, and business innovation model. The case study of Cuban universities finds out that state regulations, the closed-loop from teaching to commercialization, and the creation of hybrid knowledge structure are determinant factors in Cuban universities' transformation from traditional business model to an innovative one.

4.3. Dynamics of the Interaction of University with Other Innovation Actors in a Transnational Context

In Cai, Ferrer and Lastra's article on "Building University-Industry Co-Innovation Networks in Transnational Innovation Ecosystems" [23], they open up new horizons in research on the role of universities in innovation systems by bringing the university-industry interactions into transnational contexts and proposing an innovative method of combining theoretical modeling in social sciences research and a specific artificial intelligence technique—machine learning. Their proposed novel approach is particularly for discovering hidden-links in the transnational university-industry co-innovation networks. These hidden-links between university and industry have the potential to be utilized for trust-building and institutional change in transnational innovation ecosystems.

In Ma's article on "Developing Joint R&D Institutes between Chinese Universities and International Enterprises in China's Innovation System" [86], she uses an empirical case study approach to advance theoretical understandings of the interactions of institutional logics which result in varied patterns of a joint R&D institute co-established by a Chinese university and international enterprise. Guided by an analytical framework of institutional logics in the evolution of the Triple Helix model [87,88], this study contributes to the research gap of the university's engagement in innovation systems in a transnational context.

4.4. Academic and Student Mobility for Higher Education Innovation

The article "Mobility, Knowledge Transfer, and Innovation: An Empirical Study on Returned Chinese Academics at Two Research Universities" by Chen and Li [89] discuss the consequence of academic mobility on higher education innovation through an empirical study on returned Chinese academics at two research universities. They find that returned academics play an important role in promoting higher education innovation in China by mobilizing their transnational capital and resources. However, their capacity to innovate is largely subject to their working environment. They suggest that it is important to improve institutions' working conditions and culture in order to harvest the benefits of mobility.

The mobility of innovative resources such as talents, technology, and capital is important for the future of sustainability in higher education. However, we know little about faculty mobility from countries in which the academic profession is undergoing dramatic alterations. In their article, "Does Money Accelerate Faculty Mobility? Survey Findings from 11 Research Universities in China" [90], Liu, Yin, Lyu and Lin examine the motivations for and the outcomes of faculty mobility in the context of China by using survey data from 445 faculty members at 11 major research universities in China. They find a significant relationship between mobility frequency and indirect income. Their study suggests that more successful mechanisms to attract or retain talented scholars should be developed and that these mechanisms should not focus exclusively on income.

The study by Akhtar, Pratt and Hu, "Sustainability of the Belt and Road Initiative: An Integrated, Conceptual Framework for Instructional Communication in China's Universities" [91], develops models of instructional communication and intercultural sensitivity in learner-centered pedagogical context, for the purpose of reducing misunderstandings caused by problematic interactions between international students and Chinese faculties in the classroom. The study acknowledges the asymmetrical discourses or unequal encounters between native and non-native speakers in China's multicultural university classrooms within the context of China's dominant high-context culture. International students need to be more cognizant of the salient features of Chinese culture (e.g., differences in communication habits and in modes of thinking) and the educational system before arriving in China.

Li's study, "*How to Retain Global Talent? Economic and Social Integration of Chinese students in Finland*" [92], adopts a structure and agency approach to examine the individual and societal factors that affect international students' integration into the host environments. The data were collected through semi-structured interviews with Chinese students in Finland. Recommendations are provided for policymakers, managers of higher education institutions and individual students to advance the economic and social integration of international graduates in non-Anglophone contexts as global talents.

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Exploring the Triple Helix Synergy in Chinese National System of Innovation

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Abstract: Sustainable economic growth is closely linked to synergy in a national system of innovation. Although the dynamic synergy mechanism of the triple helix relations is essential to technology innovation, there are limited research methodologies to study or estimate the synergy effect accurately. This paper introduces a new approach in non-linear complex systems theory to offer steps towards a possible solution to this conundrum. Based on the pattern formation of the Belousov-Zhabotinsky's reaction, the paper constructs a simulation equation to explore the evolution mechanism by comparing the ideal state with the current state in China. The research finds that (1) under the ideal balanced condition of industrial absorptive capacity and academic knowledge transfer capability, the stronger incentive policies would play much more important roles than weak policies; (2) the performance of collaborative innovation is not optimal under current situation in China, but the industrial absorptive capacity, especially in private enterprises, has exceeded the capability of knowledge transfer in academia, and it has become the main driving force to promote future innovation. If the innovation policy can be focused on the high-level balance between the knowledge network and innovation network to promote synergy in China, the innovation performance will be accelerated more efficiently.

Keywords: triple helix; synergy mechanism; national system of innovation; China

1. Introduction

The sustainability of China's hitherto economic miracle is in question. As may come to pass for some developing nations, China also stands at a critical juncture between its catch-up phase that has relied on technology adaptation and one that springs from its capacity for knowledge generation and technology innovation. The national system of innovation (NSI) of a country in catch-up mode is different from one at the technology frontier. Different domestic economic and social contexts also mean that what works in the national system of innovation, synergy mechanism among university-industry-government in one country may not work in another. Sustainable economic growth is closely linked to the adaptability of NIS and the synergy of Triple Helix (TH) in NSI.

According to *the National Science and Technology Investment Statistics Bulletin 2018* issued by the National Bureau of Statistics of China on August 30 in 2019, the total national R&D expenditure in 2018 reached 19,666.7 billion yuan RMB, ranking the second in the world after the United States, which accounted for 2.19% of GDP with a total of 4.18 million R&D personnel, exceeding the average level of EU-15 countries. Among them, the expenditure of research institutions affiliated to the government is 269.17 billion yuan (accounting for 13.7%), the expenditure of colleges and universities is 145.79 billion yuan (accounting for 7.4%), the expenditure of state-owned and private enterprises is 1523.37 billion yuan (accounting for 77.4%); meanwhile, the expenditure of basic research is 109.04 billion yuan (accounting for 5.5%), the expenditure of applied research is 219.09 billion yuan (accounting for

11.1%), and the expenditure of experimental development is 163.96 billion yuan (accounting for 83.3%). Although the financial expenditure on science and technology in 2018 reached 951.8 billion yuan, considering the tax preferential policies such as additional deduction of firm's R&D expenditure and reduction of income tax of high-tech enterprises, the proportion of the government's actual investment in science and technology in the whole society has far exceeded 50% in China.

Driven by the continuous R&D investment mainly dominated by government, the number of international scientific papers and citations ranked second in the world and 244.75 million patents were authorized in 2018, however, private enterprises with less government funding have contributed 70% of the innovation outcomes. According to the latest global innovation ranking released by the World Intellectual Property Organization and Cornell University, China's innovation index in 2019, despite rising three places, still ranks 14th in the comprehensive ranking. This innovation index ranking of China is roughly in the same range as which published by China Academy of science and technology strategy, or Lausanne International School of management in Switzerland. The overall quality of NSI in China is far from meeting the requirements of building an innovative national strategy. The announcement of the 2019 National Conference on Science and Technology points out that there are some shortcomings of Chinese NSI, such as the research mechanism of key core technologies, the construction of innovation capacity, the cultivation of high-end talents, the allocation of resources, and refinement of the innovation ecology. As can be seen from the announcement, there are still some serious problems of asymmetric structure between the knowledge network and innovation network in the NSI in China. How to break down asymmetry between knowledge network and innovation network to realize higher-level equilibrium, it becomes the key point of sequential 2021–2035 National Medium and Long-Term Science and Technology Development Plan.

The synergy of NSI is closely linked to the function of TH in NSI, which is essential to knowledge generation and technology innovation of a country. Although building on the evolutionary theorizing by Nelson and Winter [1], the metaphor of NSI emerged in the late 1980s. Knowledge-Based Economy (KBE) has elaborated on NSI from an evolutionary perspective [2] since the mid-1990s, whereas TH can only be considered as an institutional elaboration [3], Due to limited research methodology to study the TH dynamic evolution mechanism of academic-industry-government relations, or to estimate accurately the synergy effect among them. This paper introduces a new approach in non-linear complex systems theory to offer steps towards a possible solution to this conundrum. Based on the pattern formation of the Belousov-Zhabotinsky (BZ) reaction, the paper constructs a simulation equation to explore the synergistic evolution mechanisms by comparing the ideal state with the current state of TH in China.

The simulation results demonstrate that (1) under the ideal balanced condition of industrial absorptive capacity and academic knowledge transfer capability, the stronger incentive policies would play much more important roles than weak policies; (2) current situation in China, the performance of collaborative innovation remains dismal at best, but the industrial absorptive capacity, especially in private enterprises, has exceeded the capability of knowledge transfer in academia, and it has become the main driving force to promote international merger and acquisition and global open innovation. If the innovation policy can be focused on the high-level balance between the domestic knowledge network and innovation network in NSI of China, the innovation performance will be accelerated more efficiently.

The subsequent parts of the paper are organized as follows. Section 2 reviews the literature on the TH in NSI. Research methods and variable refinement are discussed in Section 3, followed by Section 4 that presents the findings and their analysis. The conclusion is proposed in Section 5. The main contribution of this paper is to introduce a simulation method in non-linear complex systems theory into the research field of TH synergy in NSI, by which reveals the dynamic evolutional mechanism among TH in Chinese NSI.

2. Literature Review

Since the 1980s, market competition has become increasingly fierce, uncertainty has increased significantly, and product innovation and process innovation have shown a trend of systematization and complexity. Sahal distinguished among (i) material innovations "which are necessitated in an attempt to meet the requisite changes in the criteria of technological construction as a consequence of changes in the scale of the object", (ii) structural innovations "that arise out of the process of differential growth whereby the parts and the whole of a system do not grow at the same rate", and (iii) systemic innovations "that arise from integration of two or more symbiotic technologies" [4]. The resources and capabilities owned by a single enterprise are often unable to meet the minimum threshold requirements of complex product system. Open innovation at the micro-level and collaborative innovation at the macro level have gradually replaced the traditional closed standalone model.

After a visit to Japan, Freeman noted that Japan could be considered as NSI [5]. Lundvall further argued that interactions within national contexts might be more effective than cooperation within industry or standalone within one firm [6]. NSI combines the claims that innovation is systemic [6], that innovation systems are evolving [7] and organized institutionally, and therefore influenced by and susceptible to government policies at national or regional levels [8,9]. NSI thus seeks to combine the perspectives of policy analysis, institutional analysis, and (neo-) evolutionary theorizing [10]. In a national system of innovation, redundancy plus uncertainty (information) constitutes its maximum entropy. Redundancy can be considered as options that have not (yet) been realized, whereas uncertainty provides a measure of the options that have already been realized [11]. Increased redundancy reduces relative uncertainty [12]. Redundancy is generated in triple-helix relations because of partial overlaps in providing different meanings to the events from political, managerial, and technological perspectives [13].

The TH was first defined by Etzkowitz & Leydesdorff, in terms of links among universities, industries, and government(s) as institutional relations [3]. Etzkowitz argued that systems are innovative insofar as they generate new options from synergies among geographical, technological, and organizational factors [10]. The relations among academia, industry and government can be redefined in the light of new technological options, and institutions can substitute for each other's functions to a certain extent. Universities can take on entrepreneurial roles to engage in the wider society on all scales in order to contribute to social and economic development [14], industry can organize academic education and research, The resulting overlay of relations and communications can develop a dynamic of its own [15]. The TH perspective becomes functional because it makes the synergetic pattern of university-industry-government relations in NSI clear.

Regarding the application of TH model in China, a large number of studies have emerged for analyzing the innovation system since Zhou introduced the concept of the TH relations in NSI into China [16]. These studies include, for example, the development of the Triple Helix model in a specific industrial field [17] or a specific region [18], the technology transfer between university and industry [19]. However, few of them have tried to provide a systematic evaluation of the implementation of the Triple Helix model in China [20], hitherto, the research methodologies to study or estimate accurately the synergy effect is still limited. Leydesdorff pointed out that the three main functionalities in the TH-triangle can be considered as (i) knowledge production (carried primarily by academia), (ii) wealth generation (industry), and (iii) normative control (governance) [21]. In order to build TH indicators of synergy, academic knowledge transfer capacity, industrial knowledge absorption capacity and innovation policy are reviewed as below.

2.1. Academic Knowledge Transfer Capabilities

Knowledge transfer between academia and industry is considered an important driver of innovation and economic growth as it eases the commercialization of new scientific knowledge within firms [22]. Bloedon and Stokes defined the concept of knowledge transfer as a process, by which knowledge concerning the making or doing of useful things contained within one organized setting is brought into use within another organizational context [23]. The capabilities of knowledge generation and transfer capabilities in academia, are progressively being recognized as an important factor for structural economic growth especially in contemporary knowledge economies, and higher education institutions (HEIs) and public research institution (PRIs) are generally accepted as places for science and knowledge creation [24], as a society improves its knowledge base by creating more efficient and effective ways of functioning. The flow of information and knowledge from researchers to the wider practice community through lectures, papers, patenting, licensing, joint ventures, spin-offs and other forms of knowledge dissemination and transfer, is often ineffective and problematic, therefore leaving what is commonly referred to as the research-practice gap [25].

The gap occurs when the research undertaken by academia is thought to have little or no relevance (usefulness) to the practice or profession it is portrayed to be assisting. Issues surrounding the 'appliedness' of research have been discussed over a long period of time [26]. Biglan categorized academic fields into 'applied' disciplines, which are generally linked to theory and knowledge being applied in a practical sense, as opposed to 'basic' or 'pure' research fields, which focus on developing theoretical and conceptual understanding [27]. In an empirical investigation on maintenance management models, Fraser et al. found that a leading engineering journal had empirical evidence rates as low as 1.5%, or put another way, out of 100 published articles on the topic, only 1.5 articles presented any form of links to practice [28].

Another issue which is believed to be intertwined with the increasing problems associated with the transfer of knowledge and the research-practice gap is the ambiguity of knowledge that transferred by academics. Tacitness and explicitness (related to knowledge ambiguity) moderated knowledge transfer negatively [29]. Although most researchers feel their work has clear relevance to decision-makers, but most decisionmakers think the research community is not helpful to them [30]. Fraser et al. discuss how the manufacturing and engineering literature is saturated with sophisticated mathematical/theoretical models [31]. While the criticism is mainly anecdotal, it is argued the many academics lack practical, industry-based experience, and are training engineering students and researching innovation problems, having never worked in the industry themselves [32]. The poor-level relevance of academic research to make a difference in solving societal problems and suggest some changes which need to occur, such as the closeness of a partnership relationship, consensus of goals, tolerance of cultural differences, and so on. Therefore, this paper characterizes academic knowledge transfer capabilities with three indicators, which are useful knowledge generation ability, knowledge interpretation ability and knowledge dissemination ability.

2.2. Industrial Knowledge Absorbing Capabilities

Grant confirms the importance of knowledge as the most strategically important resources of the firm [33], Kogut and Zander maintain knowledge is the main determinant of competitive advantage [34]. Accordingly, the strategic importance of knowledge strongly reinforces the relevance of absorptive capacity as a key resource in developing and increasing a firm's knowledge [35]. The knowledge-based view of absorptive capacity is an outgrowth of the resource-based view of the firm proposed by Barney which highlights the impact of partner contributions and outward knowledge transfer to absorptive capacity. According to Barney, firm resources are all capabilities, processes, attributes, assets, information, and knowledge controlled by a firm, which can be strategically manipulated to gain competitive advantage [36]. Organizational level absorptive capacity was introduced by economists Cohen and Levinthal seminal work explaining why organizations invest in research and development [37]. Building on the concept of dynamic capability proposed by Barney, Zahra and George furthered the theoretical base of absorptive capacity as a dynamic capability related to the management and successful exploitation of knowledge [38]. The knowledge-based view of absorptive capacity stresses the importance of promoting organizational learning, developing knowledge, enhancing open innovation, managing alliances, creating strategic variety, and impacting financial performance.

The relevance of ambiguity and absorptive capacity in the context of the research-practice collaboration was confirmed by Santoro and Bierly [29]. They showed that technological relatedness and technological capability (which increases absorptive capacity) were the most important facilitators of knowledge transfer in the process of collaborations. Volberda et al. highlight the impact other factors such as a dynamic environment have on the level of absorptive capacity [35].

Absorptive capacity conceptualized an organization's ability to exploit external knowledge through a sequential process to recognize the value of external knowledge, assimilate this new knowledge through exploratory learning, and apply assimilated knowledge to create new knowledge and value. Thus, this paper uses three indicators of "knowledge exploratory learning ability, knowledge-sharing ability and knowledge application ability" to characterize the industrial absorption ability.

2.3. *Innovation Policy in China*

The knowledge emanating from research is often seen as resulting in positive externalities [39], thus exhibiting some characteristics of a public good. A public good can be defined as a good that is non-rival in its usage and is non-exclusive [40]. These properties of knowledge imply that an economy may benefit extensively from investments in knowledge development, as it tends to spill over into the economy [41]. This characteristic of knowledge as a public good does imply that markets are likely to under-supply it. The theoretical motivation for public investments stems from the notion that if the benefits of new knowledge are distributed beyond those who developed it, a market economy may generate a sub-optimal amount of research and innovation [42].

While promulgated *Outline* of the National Medium-and Long-Term Science and Technology Development Plan (2006–2020), the strategy of building an innovative country, which focused on improving triple helixes relations in NSI, was officially launched in China. Since the implementation of the plan, the R&D expenditure has been steadily improved. 94.4% of R&D funds were invested in applied research projects nowadays, but policy environments are evidently far from optimal because the technology neck problem of enterprises in various industries is still quite common, and the efficiency and effectiveness of technology transformation are still far from expected. For example, by the end of 2016 only 5034 patents and 2461 authorized patents had been transferred or licensed by 38 Central Universities in Beijing and 42 research institutes of Chinese Academy of Sciences in Beijing, accounting for only 7.8% and 9.2% of the total number of authorized patents [43].

Efforts to promote synergy of TH in NIS have been the focus of public innovation policy which concerned with fine-tuning an established system, exploring best practices of policy interventions and enabling factors of commercialization or specific transfer mechanisms. Especially in recent years, China has promoted the revision of the Law on the Promotion of the Transformation of Scientific and Technological Achievements and promulgated Several Provisions on the Implementation of the Law of the People's Republic of China on the Promotion of the Transformation of Scientific and Technological Achievements, and formulated the Action Plan for the Promotion of the Transformation of Scientific and Technological Achievements, which constitutes a "trilogy" for the promotion of the transformation of scientific and technological outcomes. At the same time, the State Council has also issued Notice of the State Council on Printing and Distributing the Construction Plan of the National Technology Transfer System and Notice of the State Council on Measures to Optimize Scientific Research Management and Improve Scientific Research Performance. In general, the optimization measures of innovation policy mainly include increasing investment in industrial R&D, improving the quality of academic research, optimizing the innovation environment and strengthening the transformation of scientific and technological achievements. Therefore, this paper uses three dimensions of "academic incentive policy, industrial incentive policy and environmental incentive policy" to characterize the current innovation policy indicators.

Based on the above literature analysis, the research framework of this paper is as Figure 1.

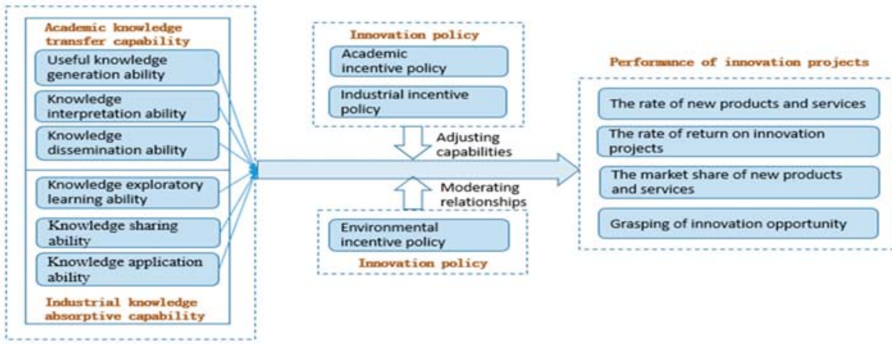

Figure 1. The research framework and relationship between main variables.

3. Simulation Model Building

In accordance with the research objectives and framework of this work, the variables and parameters should be measured to build the simulation model for exploring the dynamic evolutional mechanism of triple helix relations in NSI. Therefore, the questionnaire that uses a Likert 7-point scale to reflect the states of academic knowledge transfer capability, industrial absorptive capability and performance of collaborative innovation is constructed. Academic knowledge transfer capability is represented by three variables of useful knowledge generation ability, knowledge interpretation ability and knowledge dissemination ability; industrial absorptive capability is included by three variables of knowledge exploratory learning ability, knowledge sharing ability and knowledge application ability; the performance of collaborative innovation, is represented by four variables of the number of new products and services, the rate of return on innovation project, market share of new products and services, and grasping of innovation opportunity. Innovation policy as the intermediary variables affecting research-practice relations and innovation collaboration is represented by academic incentive policy, industrial incentive policy and environment incentive policy. Finally, the regression analysis method will be mainly used to estimate parameters (See Table 1 for details).

Table 1. Variables and parameters.

Variable	Variable Name	Variable Explanation
State variable: x_1	Industrial knowledge absorptive capacity level	To describe the level of absorbing capability in industry
State variable: x_2	Academic knowledge transfer capacity level	To describe the spill over the level of knowledge transfer in academia
State variable: x_3	Performance level of collaborative innovation	To describe the performance state of collaborative innovation
Control variable: θ	Innovation policy	General proficiency to motivate capability and relationship of TH in NSI
parameter: α	Contribution of industrial absorptive capacity	The influence coefficient of industrial absorptive capacity on the performance
parameter: β	Contribution of academic knowledge transfer capacity	The influence coefficient of academic knowledge transfer capacity on the collaborative innovation performance
parameter: γ	Innovation performance	The changing coefficient of collaborative innovation performance

3.1. Variable Measurement

A survey of the 512 industry-academic linkage projects was implemented from July 2018 to December 2018, which collected 467 answers from relative technical managers of firms in 17 high-tech industries in China. 398 effective questionnaires were obtained, with a recovery rate of 77.7%. The Cronbach α internal consistency coefficient values of the four main variables are all over 0.8, indicating that the four indicators have high internal consistency, and the questionnaire design meets the reliability requirements (See Table 2 for details).

Table 2. Result of variables measurement.

Variable	Observation Index	Mean Value	Variance	Cronbach α
Industrial knowledge absorptive capacity	knowledge exploratory learning ability	5.2377	2.4230	0.812
	knowledge sharing ability	2.6275	1.3536	
	knowledge application ability	3.6533	3.2462	
Academic knowledge transfer capacity	useful knowledge generation ability	4.1454	3.3574	0.803
	knowledge interpretation ability	2.9957	2.6548	
	knowledge dissemination ability	3.1557	3.1372	
Innovation policy	academic incentive policy	4.9643	1.3533	0.824
	industrial incentive policy	3.3455	1.3762	
	environment incentive policy	4.1532	1.5722	
Innovation performance	the number of new products and services	3.7836	3.2351	0.807
	the rate of return on innovation project	3.0354	3.1372	
	market share of new products	3.3532	3.4735	
	grasping of innovation opportunity	3.5123	4.1749	

Descriptive statistical findings that (1) the overall level of knowledge exploratory learning ability in industry has reached a high level, but there are still significant differences between individuals. Meanwhile, the level of knowledge sharing ability is generally quite low; (2) although the level of the useful knowledge generation ability in academia is relatively high, the knowledge interpretation ability and knowledge dissemination ability are still very low; (3) compared with academic incentive policy and environmental incentive policy, industrial incentive policy has not been highly recognized; (4) the overall performance of collaborative innovation projects is low, and the differences between individuals are quite large.

3.2. Estimation of Parameters

The regression model was established to estimate the coefficient parameters of variables under the influence of current innovation policies. Innovation performance is a dependent variable, and industrial knowledge absorptive capacity and academic knowledge transfer capacity are independent variables. In this paper, the average number of observation indicators is taken as a comprehensive level of relevant variables.

The regression result shows that the influence coefficient of industrial absorptive capacity on the performance of collaborative innovation is 0.675, meanwhile, the influence coefficient of academic knowledge transferability is only 0.356. Under current innovation policy, it seems certain that industrial absorptive capacity plays a more important role than the academic knowledge transfer capability during the process of collaboration between industry and academia (0.675 > 0.356) (See Table 3 for details). Considering the survey that the industrial incentive policy is lower than the enterprise's expectation, it seems to get a hypothesis that the future innovation policy should focus more on the industrial incentive policy in China. Therefore, we further explore the evolutional mechanism when innovation policy changed using the simulation model to test this hypothesis.

Table 3. Result of regression analysis.

Model	
Academic knowledge transfer ability	0.675 ** (0.102)
Industrial knowledge absorptive capacity	0.356 ** (0.097)
Constant	−12.374 **
F	78.464 **
R^2	0.823

Note: the figures in the table are estimated values of parameters, and the values in brackets are estimated standard errors. *** means significant at the level of 0.01, ** means significant at the level of 0.05, * means significant at the level of 0.10 (bilateral test).

3.3. Model Selection

Model selection. The Belousov-Zhabotinsky's (BZ) reaction is an experimentally accessible example of chemical self-organization [44,45]. In the 1970s, nonlinear oscillations and bifurcations were discovered first by modelling and then by experiments for the autocatalytic Brusselators and the BZ chemical reaction [46]. The autocatalytic chemical reaction phenomenon plays a vital role in the breakdown of the stability of the thermodynamics. Self-organization phenomena, leading to ordered behavior, can arise in an initially uniform and time-independent system far from equilibrium. Their interest arises primarily from the fact that the emergence of order is often accompanied by the appearance of spatially asymmetric patterns. Such symmetry breaking phenomena are therefore of special interest in modeling the behavior of complex objects, where both order and asymmetry are ubiquitous [47].

The self-organized pattern formation of non-linear complex systems has very useful applications in many fields of social science as well. In China, Brusselator model was firstly taken by Li as the judgment tool of dissipative structure threshold [48], Li et al. studied the evolutionary mechanism of industry and university alliance based on 2-D system dynamic equation [49], Zhang et al. built the 3-D variable model to introduce "BZ" reaction for studying the evolutional mechanism of the enterprise system [50]. In this work, we use the 3-D variable model to explore university-industry-government relations in the national system of innovation.

A class of problems for which system self-organizing has been particularly well studied is described by the so-called BZ reaction equations [51]. BZ reaction is the typical system with self-organization property. It specifically refers that the chemical oscillation phenomenon occurs when citric acid is oxidized by potassium bromate under the acidic conditions with metal cerium ion as catalyst, and furthermore, certain rhythmicity in time also exists there, namely, color rectilinear oscillation occurs in the solution between achromatic color and faint yellow. According to Prigogine's explanation of the oscillating reaction: when the system is far away from the equilibrium state, namely, nonequilibrium nonlinear region, unordered even state is not always stable [52]. Under the specific dynamic conditions, unordered even stationary state can be out of stability and generates time-space ordered new status. At the microscopic scale, it seems unordered that microscopic particles of various reacting matters make random motions and collisions, but at the macro level, the reaction is ordered in both space and time.

The system variables can be divided into fast and slow variables, and the slaving principle is found by the synergistic theory [52], namely, slow variable dominates the progress and result of the system evolution and development, under the condition of threshold value, such slow variable becomes the dominant variable, and other variable becomes slaving variable. The slaving principle in the self-organization synergy theory provides the possibility for the establishment of the simulation equation to study the dynamical mechanism of the TH synergy in national system of innovation.

Feasibility analysis. The innovative dynamics are endogenized and the relations among the agents reconstructed by the dynamics of innovations [10]. In other words, the innovation system is a self-organizing system. Prigogine noted that a synergistic self-organizing system must also possess four general conditions: far from equilibrium, openness, nonlinear interactions and fluctuation [53]. Using self-organizing synergy theory as a research fulcrum, it should be confirmed that national system of innovation meets all prerequisites of a synergetic self-organizing system.

The national innovation system has the attributes of synergetic self-organizing system: (1) Open innovation theory proposed by Chesbrough shows that openness is the important prerequisite and approach to improve innovation performance, the opening degree between system innovative actors directly decides the effect of performance of innovation [54]. In the network-based and knowledge-based economy, the innovation system has evolved into an open era from the traditional closed standalone pattern, and furthermore, the university-industry-government linkage becomes the core of the national open innovation system. The process of industry-university collaborative innovation is the knowledge-core value innovation process for information sharing, knowledge production, knowledge spread and application [55]. Therefore, Haken points out that it is more suitable for replacing thermodynamic entropy into information entropy for understanding the nonequilibrium social systems [56]. (2) Christensen considers that innovation is divided into incremental innovation and disruptive innovation, and the different fluctuation rules are revealed in the innovation process [57]. (3) The concept of knowledge transfer has been proposed by many scholars while studying asymmetric knowledge distribution [58]. Cohen and Levinthal reveal the vital role of the absorptive capacity in knowledge transfer [59], and subsequently explorative and exploitive organizational study are proposed by March [60] to deepen the connotation of organizational absorptive capacity. Above all, it is obvious that NSI meets all the preconditions of the self-organizing synergistic system to apply B-Z reaction for the simulation study.

3.4. Model Building

The synergistic theory, namely system variable, is divided into fast and slow variables [29]. It is referenced to explore the slaving principle that slow variable dominates the development course and result of the system evolution. Following literature reviews and empirical research above, three key variables of national system of innovation had been refined which are: the academic knowledge transfer capability, the industrial knowledge absorptive capacity, and finally the performance of innovation. However, how the national system of innovation will gradually progress was still unknown when innovation policy context or capabilities change. This paper builds a three-D equation set based on BZ reaction, to explore the dynamic mechanism of TH when innovation variables change over time.

Dynamic evolution equation of industrial knowledge absorptive capacity. Under the original state of academia and industry linkage, explicit knowledge transfer is given priority. While the proportion of the tacit knowledge increases overtime, firms may fail to improve absorptive capacity synchronously and academic researchers may be limited by their knowledge interpretation and dissemination abilities, the knowledge transfer becomes more difficult. In addition, it is obvious that innovation performance is always influenced by incentive policy. Therefore, under the certain condition of incentive policy θ, logistic evolution equation of state variable of industrial knowledge absorptive capacity is as follows:

$$\frac{1}{\alpha}\frac{dx_1}{dt} = \theta x_1 + \theta\frac{\beta}{\alpha}x_2 + \gamma x_1 x_3 \tag{1}$$

In which, θx_1 is the autocatalytic factor under the incentive policy context, θ reflects the role of innovation policy to x_1. $\theta\frac{\beta}{\alpha}x_2$ is the impact factor of x_2 on x_1 under incentive policy context θ, $\frac{\beta}{\alpha}$ is influence coefficient. HEIs and PRIs' knowledge transfer promotes the enhancement of firms' absorptive capacity. $\gamma x_1 x_3$ shows the feedback influence of innovation performance x_3 on x_1, the endogenous promotion of enterprises' innovation performance will act on more research input of enterprises and enhance their technology capabilities, which weakly depends on whether it is driven by policy.

Dynamic evolution equations of academic knowledge transfer capability. In an initial state, HEIs and PRIs are the important knowledge sources for the industry to improve technology capabilities and innovation performance in the knowledge-based economy. Academic knowledge transfer capability is influenced by both industrial absorptive capability and innovation performance in the evolutional process. Therefore, under the certain condition of incentive policy θ, logistic evolution equation of academic knowledge transferability is as follows:

$$\frac{1}{\beta}\frac{dx_2}{dt} = -\theta x_2 - \alpha x_1 x_2 + \frac{\gamma}{\beta}x_3 \tag{2}$$

In which, $-\theta x_2$ means the autocatalytic factor of x_2 under incentive policy. Its coefficient is negative, showing that with the constant improvement of academic knowledge transfer capability in HEIs and PRIs, marginal income decreases progressively because HEIs or PRIs fall into the dilemma situation: focusing on knowledge production or knowledge commercialization under their limited resource conditions and time. $-\alpha x_1 x_2$ shows the influence factor of x_1 on x_2, under assured incentive policy θ. The enterprise is also faced up with the difficult choices: enhancement of R&D or improvement of absorptive capability. $\frac{\gamma}{\beta}x_3$ is the influence factor of collaborative innovation performance on academic knowledge transfer capability there exists positive incentive effect of the promotion of innovation performance on academic knowledge transfer capability, and $\frac{\gamma}{\beta}$ is the influence coefficient.

Dynamic evolution equation of collaborative innovation performance. The purpose of innovation in the industry is to finally achieve commercial successes by means of open absorption and utilization of heterogeneity knowledge. So collaborative innovation performance is essentially only related to its own state level of absorptive capability of firms. Therefore, under the certain condition of incentive policy θ, logistic evolution equation of state variable is as follows:

$$\frac{1}{\gamma}\frac{dx_3}{dt} = \eta_1 x_3 + \eta_2\theta\frac{\alpha}{\gamma}x_1 \tag{3}$$

In which, $\eta_1 x_3$ is the autocatalytic factor of collaborative innovation performance, the pressure of market competition and endogenous innovation dynamics make the state of innovation performance in the rising trend. η_1 is constant normally. $\eta_2\theta\frac{\alpha}{\gamma}x_1$ is the impact factor of absorptive capability on the performance of collaborative innovation. The external incentive policy acts on the collaborative innovation performance via absorptive capability finally, embodying that with the improvement of absorbing ability, collaborative innovation performance promotes. $\frac{\alpha}{\gamma}$ is the influence coefficient, η_2 is constant. Generally, η_2 is normally more than 1, embodying the synergistic effect of industry-university linkage. The reason why the knowledge transfer variable x_2 is not included in the equation is that the collaborative innovation performance is finally reflected in the enterprise's innovation performance. The direct impact mechanism of academic knowledge transfer on innovation performance is not clear. $\eta_1 = 2$ is supposed in this paper, which reflects that the endogenous power of industry-university linkage promotes the innovation performance, showing the Matthew Effect. If $\eta_1 = 2$, it reflects that the innovation performance is multiplied by the synergistic effect of TH under the condition that innovation performance is promoted by absorbing capability.

Dynamic evolution equations of TH synergy. Combining the above three equations, this paper constructs the following dynamic evolution equations of TH synergy:

$$\begin{cases} \frac{1}{\alpha}\frac{dx_1}{dt} = \theta x_1 + \theta\frac{\beta}{\alpha}x_2 + \gamma x_1 x_3 \\ \frac{1}{\beta}\frac{dx_2}{dt} = -\theta x_2 - \alpha x_1 x_2 + \frac{\gamma}{\beta}x_3 \\ \frac{1}{\gamma}\frac{dx_3}{dt} = \eta_1 x_3 + \eta_2\theta\frac{\alpha}{\gamma}x_1 \end{cases} \tag{4}$$

4. Simulation Results

In this paper, it is set that in the differential equation, the initial state of the three variables of industrial absorptive capacity, academic knowledge transfer and collaborative innovation performance is $X_0 = [x_1, x_2, x_3]$. The x_1, x_2, x_3 respectively represent the input condition of the three factors of TH statuses before collaboration. At the same time, being specific to the incentive effect generated by external policy environment, there are two conditions divided in this paper: (1) Set the control variable incentive policy $\theta = 1$, it reflects normal support of the country and regional government to the collaborative innovation, the implementation of collaborative innovation under spontaneous condition; (2) set control variable incentive policy $\theta = 2$, it reflects that the country and region give stronger policy support to collaborative innovation, by means of offering necessary infrastructure input, talent input, innovation service support and other incentive mechanism to carry out collaborative innovation, so as to push the implementation of collaborative innovation activities.

It is also specific in this paper to two states of Triple Helix, based on MATLAB simulation analysis software, the studies will be respectively implemented: (1) The ideal status when absorptive capacity and transfer ability are at higher level symmetry, the TH synergy mechanism under two different incentive policy contexts are simulated. (2) The second status is under the current condition in China based on empirical statistical data studied ahead.

4.1. Simulation When Capabilities Balance between Industry and Academia

Under the balanced condition of absorptive capacity in industry and knowledge transfer capability in academica, we suppose that the performance of collaborative innovation relies on the further implementation of collaborative linkage. Therefore, it is respectively defined that industrial absorptive capacity is 1, academic knowledge transfer ability of is 1 and collaborative innovation performance is 0 (due to certain time delay) for the initial state of the simulation. Namely, under initial state $X_0 = [1, 1, 0]$, the study is respectively implemented according to the two conditions of normal incentive policy ($\theta = 1$) and strong incentive policy ($\theta = 2$).

Normal incentive policy context. The simulation result of dynamic mechanism in NSI under normal incentive environment ($\theta = 1$) is shown in Figure 2, y_1 is industrial absorptive capacity, y_2 is academic knowledge transfer capability and y_3 is collaborative innovation performance.

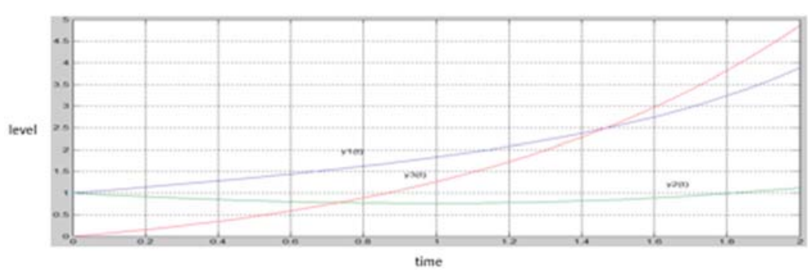

Figure 2. Dynamic evolution mechanism under the normal incentive policy.

Simulation results: Under the condition of normal external incentive policy context, when x rises to 2, innovation performance is close to 5. The rapid promotion of collaborative innovation performance appears, and absorptive capability is improved rapidly at the same time, and the academic knowledge transfer ability of colleges and universities maintains stable and rises slowly.

Result analysis: (1) Under the condition of weak external incentive policy, because of the comparative matching of knowledge supply capability and knowledge absorptive capability, heterogeneous knowledge accumulated by universities has become the main target for enterprises to absorb, which has rapidly improved the innovation ability and innovation performance of enterprises.

(2) In the initial stage, the participation of agents in HEIs and PRIs in collaborative innovation projects has spent a lot of energy, and academic productivity has been affected to a certain extent. (3) The result of long-term interaction between university and enterprises respectively promote their technology capabilities from collaboration.

Stroger incentive policy context. The simulation results of the collaborative innovation mechanism under a strong incentive environment ($\theta = 2$) is shown in Figure 3.

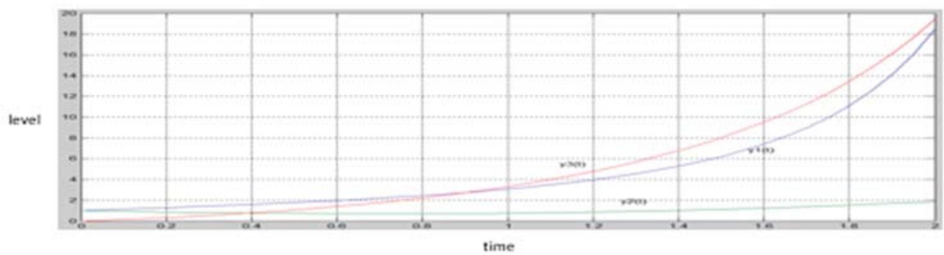

Figure 3. Ideal dynamic mechanism of NSI with stronger incentive policy.

Research results: Under the ideal condition of stronger incentive policy, industrial absorptive capacity, academic knowledge transfer ability and collaborative innovation performance show the same variation trend with the normal incentive policy, but collaborative innovation performance gets the rapid promotion. Under the condition of x = 2, innovation performance is 19, which is 4 times of the normal incentive policy. At the same time, the absorptive ability is improved synchronously, and knowledge transfer capability shows the secular change trend of firstly dropping and then rising.

Result analysis: The result proves that national or regional innovation policy has the positive effect of promoting absorbing ability and innovation performance when the capabilities of agents match in NSI. It might be four reasons: (1) Innovation policy fosters consensus of synergistic innovation, which reduces the cost of technology transaction. (2) Innovation policy increases investment in innovation infrastructure and enterprise innovation resources, which promote the motive force and capability of synergistic innovation in industry. (3) Innovation policies have increased investment in innovative resources such as university human resources and research funds, which better balance the relationship between innovative services and scientific research. (4) HEIs and PRIs learned heterogeneous knowledge from the industry which promoted the continuous improvement of academic research abilities over time, also strengthened their motivation to participate in collaborative innovation activities for knowledge commercialization.

4.2. Simulation Based on Current Situation in China

According to the empirical results ahead the influence coefficient of industrial absorptive capability on innovation performance is 0.675, while the influence coefficient of unit knowledge transfer ability to innovation performance is 0.356. Based on the results of the questionnaire, the evaluation of innovation policy by the industry is in the middle level. Therefore, this paper sets the influence coefficient of incentive policy on the performance of collaborative innovation is 1.166. It is confirmed that initial state X_0 = [0.675, 0.356, 0] to obtain simulation result of Figure 4. In which, y_1 is industrial absorptive capacity, y_2 is knowledge transfer ability of HEIs and y_3 is collaborative innovation performance.

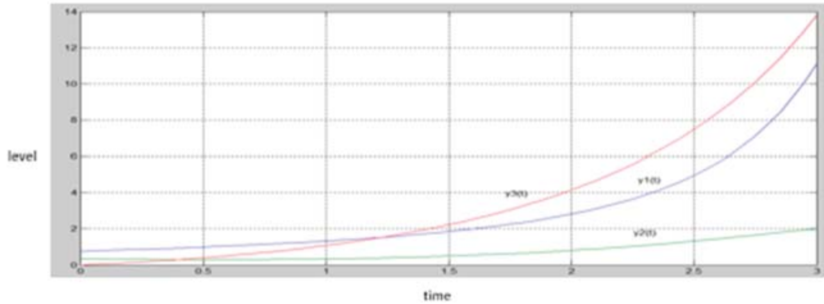

Figure 4. Dynamic mechanism of TH synergy in China.

Simulation results: Under the current situation of NSI in china, the synergy of TH is still far from optimal. However, innovation performance is slightly higher than 4 if x = 2, and innovation performance starts to show rapid growth trend, may up to 14, if x = 3. Absorptive capability in industry is in high correlation with innovation performance with system evolution and time advance. Knowledge transfer ability of HEIs and PRIs slowly rises, while the evolutionary trend is stable. The result shows that China's national system of innovation has good prospects for development, and innovation performance will face a significant growth trend over time. (1) In the current situation, the absorptive capacity in industry has exceeded the ability of knowledge transfer of HEIs and PRIs, and it has become the main driving force to promote innovation and development. (2) At present, the level of absorptive capacity has been higher than the level of innovation performance. From the analysis of the evolution progress viewpoint, the role of absorptive capacity and innovative capacity in industry will be gradually revealed, which will sustainably and rapidly improve the innovation performance of national innovation system in future.

Results analysis: (1) while the breadth and depth of open innovation have been continuously expanded, industrial absorptive capacity has become the core competence of collaborative innovation. This result elaborates that industrial absorptive capacity is highly correlated with TH synergy. If the absorptive capacity in industry is insufficient, the efficiency of knowledge transfer will also be affected prominently. Not only the cooperation cycle between university and industry becomes long and tough, but also the important and limited resources may be exhausted. When the industrial absorptive capacity matches the academic knowledge transfer capability, the performance of collaborative innovation and the quality of national innovative ecology can be significantly improved. Above all, the industrial absorptive capability plays an important role in TH synergy in NSI. However, while the improvement of industrial capability, the problem of knowledge sharing within the organization is particularly prominent. On the one hand, with the increase of the mobility of enterprises' technical personnel, setting up technical firewalls has become the main strategy of personnel which limits the sharing of knowledge; On the other hand, enterprises still do not pay much attention to knowledge management, which also greatly affects knowledge sharing in the team and organization level. (2) Knowledge transfer capability of HEIs and PRIs shows relative stability. Based on the synergistic theory, the evolution of the system is dominated by slow variables. The knowledge transfer capability of HEIs and PRIs has obviously become the dominant variable that affects triple helix's synergy. In other words, the capabilities of useful knowledge generation, knowledge interpretation and dissemination, already become a bottleneck problem in NSI of China. Evidence also found that with the enhancement of the industrial absorptive capacity, Chinese enterprises are more willing to acquire technology through international merger or global cooperation than local collaborations, which affects the cooperation of domestic universities negatively [61]. With the continuous support of national scientific research investment, universities and scientific research institutions have published many high-quality papers and applied for a large number of patents, but obviously there is a gap between the knowledge demand of real innovation context and supply from the HEIs and PRIs.

5. Conclusions

Based on BZ reaction model in non-linear complex systems and MATLAB simulation analysis software, this work introduces a new simulating method to explore the synergistic mechanisms of TH in NSI, and obtained an important conclusions: The hypothesis that the future innovation policy should mainly focus more on the industrial incentive policy in China might not be comprehensive. Innovation policy plays a positive role in promoting the collaborative innovation capability and performance in NSI, and policy objectives need to be targeted at solving bottleneck problem at priority. At present, innovation policy in China faces a dilemma, that is, to continuously increase governmental direct investment in basic and applied research to improve knowledge supply capacity, or to incentive industrial investment to improve knowledge integration and application capacity.

Based on the results of empirical research and simulation research, this paper considers that the domestic academic knowledge capacity is the order variable which dominant the evolution of TH in Chinese NSI. Optimizing governmental direct R&D investment mechanism should be the top priority, especially the application research project funding which accounts for a very high proportion. Although the main goal of applied research projects funding is to promote technology commercialization, the current criteria for competition are mainly composed of published papers, applied patents and previous project experience. Therefore, in order to obtain more governmental funding supports, researchers both in academia and in industry inevitably spend much more time and energy in publishing papers or applying for patents, and ultimately have no energy and motivation to implement commercialization.

Additionally, the incentive policies to encourage industrial innovation investment also need to be further subdivided. In addition to increasing the R&D investment efficiency of state-owned enterprises, how to eliminate the barriers between knowledge production and knowledge circulation may be the key issue of industrial innovation policy. Although the construction of intellectual property regimes has been paid more and more attention to for a long time, and the intellectual property courts also be constructed as a policy innovation pilot, the implementation process of intellectual property regimes is plagued by problems, such as difficult to obtain infringement evidence and the lack of enough supervisors, etc. Most private enterprises prefer to choose management measures to avoid R&D investment or to acquire oversea knowledge by means of strict internal prevention of knowledge sharing, in order to reduce the externality of knowledge spillover. So, optimizing the enforcement mechanism of the intellectual property regimes may also be the key link to eliminate the bottleneck of collaborative innovation.

In summary, if the innovation policy can be more targeted at the upgrading of the domestic supply capacity of useful knowledge in HEIs and PRIs as optimization objectives, at the same time continue to strengthen the implementation of the intellectual property protection regimes, the synergy quality of national innovation system in China would be continually improved, and the endogenous innovation performance would be accelerated rapidly.

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An Empirical Study of the Role of Higher Education in Building a Green Economy

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Abstract: The relationship between higher education and economic development has long been emphasized in the research on economics and education. Much of the existing literature focuses on the gross domestic product (GDP) as a core measure of a nation's economic accounting system, but this may neglect some negative effects of production, such as resource depletion and environmental damage. Under such circumstances, the concept of "green GDP" was conceived to consider environmental influence simultaneously with the economy. It is, however, only theoretically feasible due to the complexity in calculating environmental pollution and the unavailability of data about resource consumption. Considering the measurement problems, this paper proposes a new approach to indirectly estimate green GDP. Using this approach, we mainly explore the impact of higher education on economic growth, especially regarding the development of a green economy. Results show that (a) higher education plays a significant role in building a green economy, and (b) green GDP is more responsive to changes in higher education than the traditional GDP. This study provides empirical evidence for the substantial contribution that higher education makes in promoting green economic growth to achieve comprehensive sustainable development.

Keywords: higher education; green GDP; environment; sustainable development

1. Introduction

It has been widely recognized that education has a significant positive effect on economic growth. Theodore W. Schultz argued in the human capital theory that education can help accumulate people's human capital so as to enhance their productivity in labor market [1]; this has been confirmed by empirical research in different countries and regions [2,3]. Higher education, in this way, plays an even more prominent role in economic development. Not only does it cultivate high-quality labor to increase the productivity of the whole society, but it also promotes technological and institutional innovation in order to improve the efficiency in production. Moreover, it should also be noted that higher education benefits people with knowledge and skills, and also changes their daily behaviors, or even shapes people's views and values in every way. All these possible effects of higher education on people will ultimately exert some impact on economic development, since the labor force is one of the basic factors in production [4]. Therefore, it is quite necessary to comprehensively explore the role of higher education in economic growth from different perspectives.

Previous research on higher education and economic development mostly employed traditional GDP as the measure of economic growth; however, this practice has long been critiqued, with the concern that GDP cannot accurately reflect the welfare of a nation. Even Richard Stone, one of the creators of the original GDP indicator, suggested that "the three pillars on which an analysis of society ought to rest are studies of economics, socio-demographic and environmental phenomena" [5].

The concept of green GDP emerged in this context, aiming to make up for the shortcomings of traditional GDP accounting. In contrast with the limitations of traditional GDP, green GDP essentially stands for the net positive effect of national economic growth. Nevertheless, there were many difficulties in calculating green GDP in empirical studies. Intuitively, we can get green GDP by deducting the costs of environmental consumption and pollution from the traditional GDP, but this is mainly theoretically feasible considering the complexity in calculating environmental pollution and the unavailability of data about resource consumption. Given these research gaps, is it possible to propose a new approach to indirectly estimate green GDP? How does higher education affect green economic development? Is there any difference of the role higher education plays in green GDP and in the traditional GDP? Our paper contributes by answering these three research questions. The contribution and limitations of prior literature in this field need to be reviewed and analyzed before we continue our research.

2. Literature Review

This section mainly consists of three parts: First, it brings in the typical Solow–Swan growth model as well as its modified versions that are commonly used considering economic growth, which will also prepare our analysis later in the research design section; second, it presents a review of previous studies about the impact of higher education upon economic development, based on which the third part identifies and elaborates the research gaps, i.e., the limitations of traditional GDP measure and the difficulties in calculating green GDP in empirical research.

2.1. Economic Growth Model

Solow–Swan growth model is one of the classical models of economic development, which is also known as neoclassical economic growth model or exogenous economic growth model. It was developed by Solow to theoretically analyze the relationship between savings, capital accumulation, and economic growth within the framework of neoclassical economics [6]. The basic form of Solow–Swan model is as follows:

$$\mathrm{Y} = \mathrm{A}K^{\alpha}L^{1-\alpha}. \tag{1}$$

Y refers to the economic growth measured by GDP, while the three independent variables K, L, and A, respectively, represent capital, labor, and other factors in production such as technological development. This fundamental model has been developed in later research, mostly by separating other influencing factors from the variable A. For example, Barro and Sala-i-Martin [7] modified this model by taking knowledge and technology (variable T) into account:

$$\mathrm{Y(t)} = \mathrm{F[K(t),\ L(t),\ T(t)]}. \tag{2}$$

Mankiw, Romerm and Weil [3] developed a Mankiw–Romer–Weil version of the model considering human capital (variable H) in their analysis:

$$\mathrm{Y(t)} = \mathrm{F[K(t),\ L(t),\ H(t)]}. \tag{3}$$

Furthermore, the "new growth theory" developed by Romer and Lucas highlighted the role of knowledge and technology and suggested technological progress was the determining factor to ensure sustainable economic development.

These modifications of Solow–Swan model may be used in various contexts based on their applicability. The Mankiw version, for instance, can be used to explain why capital always flows from labor-intensive poor countries to the developed countries. In general, the Solow model has been recognized as the most fundamental and commonly used version in pertinent studies of economic growth, which will also be employed in our study.

2.2. Impact of Higher Education on Economic Growth

Prior research about the impact of education on GDP were often based on human capital theory, according to which human capital is tightly related to education and makes great contribution to economic growth. Lucas proposed that human capital is accumulated by both education in school and learning in practice. School education forms general human capital, which determines, to a large extent, the accumulation of specialized human capital generated via work experience. In workplaces, it is difficult to acquire human capital for people with a low educational level [8]. Therefore, education, serving as a prerequisite for human capital accumulation, is commonly employed as a proxy variable when analyzing the significance of human capital on economic development.

Most of the empirical research consistently concluded the positive effects of education at all levels on economic growth. Kyriacou proved that the stock of human capital was positively related to a nation's economic growth by using the data on average years of schooling as a proxy for human capital and regressing the Lucas endogenous economic growth model [9]. Barro and Lee explored how a set of quantifiable explanatory variables gave rise to differences in growth rates across countries, identifying the significant role of secondary-school attainment in the growth regression [2]. Apart from the general consideration, there were some research looking into the role of education in different contexts. For example, Yang, Gong, and Zhang used the panel data of 29 provinces in China during the period 1985–2000 and analyzed how education influenced economic development with the Solow model, measuring education by the proportion of people at least graduating from junior high school among the population aged 15 and over. It turned out that education had a significant positive impact on economic growth and the coefficient was much higher compared to other similar international empirical studies [10]. Interestingly, Wang, Fan, and Liu measured the educational level with an index calculated from average education years of the working population, and the coefficient in the Solow model indicated much less of an effect of education on economy in China in comparison with other countries like the United States [11]. Notwithstanding the disaccord in different degrees of the importance of education by using different measures, they did agree on the key role of education in promoting economic growth. In addition, there were also some studies comparing the heterogenous effects of different educational levels on economic growth, highlighting that globally, countries with higher enrollment rates in secondary and higher education have grown faster economically [12].

Particularly for the impact from higher education, Yue made an international comparison of the status of higher education and economic development from 1978 to 2017, and the results indicated that there was heterogeneity among different countries, with a more pronounced influence in developed countries [13]. Gyimah-Brempong, Paddison, and Mitiku found a significant relationship between higher education capital and the growth rate of per capita income in African countries [14]. Tin-Chun Lin focused on the role of higher education on economy using data from 1965 to 2000 in Taiwan, and found that higher education, particularly the fields of engineering and natural sciences, contributed greatly to economic growth [15]. Song and Wang showed that the labor productivity of higher education graduates was 2.17 times higher than that of primary education graduates; yet the contribution to economy was limited to the small scale of higher education in China [16]. Despite different empirical conclusions of relevant studies with various databases and methodologies, a general consensus has been reached that higher education promotes the sustainable economic growth and human capital may be the core driving force for sustainability.

2.3. Research Gaps

2.3.1. Limitations of Traditional GDP as a Measure of Economic Growth

In the existing literature, the traditional national economic accounting system has long been used to estimate the contribution of education to economic growth. Dating back to the 1940s, many Western countries pursued Keynesianism, which inspired government intervention in the national economy. In light of the government involvement, it was essential to analyze economic development macroscopically. To achieve this goal, Kuznets, Epstein, and Jenks [17] then proposed the concept of gross national product (GNP), from which the gross domestic product (GDP) derived. Later, the United Nations adopted GDP as an important indicator of economic growth worldwide. At that time, the theory of property rights still needed to be further developed and improved, while natural resources and the ecological environment were regarded as free public goods, so they were excluded from the accounting system.

Nevertheless, in recent years, environmental deterioration with the shortage of resources globally has posed an unprecedented and grave threat to human development. This has raised people's awareness of the need for environmental preservation. Under this circumstance, the limitations of traditional GDP became evident. On the one hand, human economic activities have positively influenced society by creating wealth; on the other hand, the same activities have brought in negative effects by hindering the development of social productivity in many forms. For instance, relentless overexploitation has resulted in the diminishing supply of natural resources. Moreover, the discharge of sewage and waste, as well as deforestation, have been major contributors to environmental degradation. These downsides, however, have not received adequate attention. The current national economic accounting system only looks at the bright side of economic activities, which does not reflect practices of sustainable development.

Taking the trajectory of the Chinese economy as an example, in the year 1980, China was the most populous yet one of the poorest countries. Within approximately three decades, however, it has taken a significant leap, becoming the world's second largest economy only after the United States, which was exclaimed by many international media as the "Chinese miracle" [18]. Unexpectedly, in recent decades, the Chinese economic boom has started to tail off, with some social conflicts—previously concealed by the economic prosperity—standing out. One of the major problems was the imbalance in national industrial structure. The central government was forced to cut capacity in sectors such as coal and steel and to facilitate the deleveraging process, which, inevitably led to mass unemployment [19]. Furthermore, China's development has overlooked the destruction of environment and immoderate consumption of non-renewable resources; this, in turn, brought about environmental deterioration, such as more serious water pollution and an increase in carbon dioxide emission. Fortunately, this issue has been receiving more attention than before, given the improved living standards of Chinese people and increased public awareness in environmental protection. With this particular case of China, it is apparent that the traditional measurement of economic development merely by GDP may be misleading, and we are in urgent need to embrace new approaches to gauge economic growth, thereby guaranteeing the long-term benefits for human beings.

2.3.2. Difficulties in Measuring Green GDP in Empirical Analysis

"Green GDP" was conceptualized to consider environment on an equal footing with economy. It refers to the results of economic activities while also considering their impacts on natural resources (mainly including land, forests, minerals, water, and oceans) and the environment as a whole (such as ecological, natural, and human environments) [20]. In other words, green GDP takes into account the costs of resource depletion and environmental degradation incurred in economic activities. Green GDP is regarded as the indicator for sustainable economic development for several reasons. First, it measures the actual achievements in productivity in order to avoid pure pursuit of economic growth rate that neglects the externalities of economic activities. Second, it mirrors the scenarios of social welfare and progress, highlighting the importance of coordinating harmonious development of man and nature. Meanwhile, green GDP helps enhance public awareness in environmental protection and promote the transformation of development patterns. Nevertheless, this does not mean that the traditional GDP should be replaced by green GDP as a better solution. The traditional GDP is still the most important and direct indicator reflecting the levels of national economic development, while green GDP serves as a supplement in an ecological manner.

As early as 1971, the concept of "Eco-Requirement Indication (ERI)" was proposed by the Massachusetts Institute of Technology to reflect the relationship between economic growth and environmental resource pressure [21]. In the 1980s and 1990s, the World Bank tried to spread "green accounting" [22] and established the system of environmental economic account (SEEA) in some countries. However, this approach has not been applied extensively and most countries and regions barely take into account their natural resources and environmental conditions nationwide when assessing the economic growth. For example, China, in 2006, first published the research report of green national economic accounting of 2004, but there were no subsequent reports due to the accounting difficulties and data unavailability.

Generally, most of the previous research on green GDP were still at the exploratory stage, trying to discuss and develop green GDP theoretically considering its calculation difficulties. Boyd discussed the possibility to measure non-market value of natural resources in his article and proposed that national culture and social stability should be included when evaluating green GDP [23]. Li and Fang employed the ecological and geological methods to measure the consumption of global natural resources, with the purpose of calculating the green GDP of different countries [24]. There were also some other scholars who made intensified efforts to calculate green GDP using the input–output model. This model assessed the national inputs and outputs in industry, energy, transportation, and agriculture based on the environmental and economic account of World Bank. On this basis, the scholars adjusted GDP values by considering the actual consumption in various sectors. So far, they have calculated green GDP for different countries and regions, including Australia [25], Austria [26], Brazil [27], and Italy [28,29], the Netherlands [30], Sweden [31], the United Kingdom [32], and the United States [33], etc. Even so, it was still not easy to measure the resources and environmental inputs required in various industries, so this input–output model posed similar challenges in complexity and precision during calculation compared to the previous models. Furthermore, other studies focused on the determinants of green GDP. Talberth and Bohara found that the openness of countries was significantly negatively correlated to national green GDP, while there was a positive correlation between the countries' openness and the difference between their green GDP and traditional GDP [34].

Overall, higher education has positive effects on economic growth. Nevertheless, when measuring economic growth, traditional GDP may neglect some negative effects of production, such as resource depletion and environmental damage; while green GDP, though considering environmental influence simultaneously with the economy, is only theoretically feasible due to the complexity in calculating environmental pollution and the unavailability of data about resource consumption. Our paper aims to fill these gaps by proposing a new approach to indirectly estimate green GDP, and identifying how higher education exerts differential effects on green GDP and on the traditional GDP.

3. Research Design

3.1. Hypotheses

Our paper proposes a new approach to indirectly estimate green GDP, and based on this indicator, it is designed to address two main questions: (1) How does higher education affect green economic development? (2) Is there any difference of the role higher education plays in green GDP and in the traditional GDP? According to the prior literature, the traditional GDP is inextricably linked with higher education, and it is quite meaningful to evaluate the effect of higher education on green economic growth. Furthermore, to compare the different impacts on green GDP and the traditional GDP will offer us an in-depth understanding of the role of higher education. It is very convincing that countries with higher levels of education on average may have higher quality of human capital and more optimized industrial structures, which allow them to utilize resources in a more efficient and environmentally friendly way. Thus, this paper puts forward two main hypotheses to verify.

Hypothesis H1: *Higher education has positive influence on building green economies.*

Hypothesis H2: *Green GDP is more responsive to changes in higher education than the traditional GDP.*

3.2. Green GDP Calculation

Though the concept of green GDP has been proposed long ago, prior research had not made satisfactory achievements, given that there was no sufficient data to support the theoretical models by deducting costs of natural resources and environmental pollution from the traditional GDP. Our paper tries to measure green GDP from the perspective of the efficiency of energy resources utilization, which is regarded as one of the fundamental differences between the traditional and green economic development. In practice, we adopt two variables accordingly, one of which is the rate of energy use, calculating how much monetary output can be produced by one unit of energy resources. The other refers to the ratio of renewable energy of the total, which is more about assessing the damages caused by production. Therefore, we create a new indicator "green GDP" here to assess the development of green economy to some extent:

$$\text{GreenGDP} = \text{GDP} * \textit{energy} * \textit{renew}. \tag{4}$$

The variable *energy* is measured by the GDP produced through consuming per unit of energy resources, while *renew* represents the proportion of renewable energy of the total, an indicator of environmental damages. It can reflect the environmental pollutions caused by excessive consumption of fossil fuels and their irreparable dangers and damage to human society. Usually, the higher the share of renewable energy is, the more clean energy can be used and the less waste will be produced. Here, the term "green GDP" stands for both the domestic productivity and energy efficiency as well as environmental preservation of a country or region.

In this way, the rates of energy utilization and the proportion of renewable resources are much more accessible. However, this method has obvious weaknesses. It cannot be considered as the real green output of a country, but merely an indicator logically related to green GDP, so the absolute value generated from this equation has little practical significance. In spite of this, the indicator still reveals the costs in resources and environment to a certain extent. When studying the economic growth of countries, usually we are more concerned about the relative changes than the absolute values of economic output. Therefore, it is still meaningful to focus on the diachronic changes and cross-country comparison by applying this approach in economic analysis.

3.3. Modified Solow–Swan Model with Higher Education

In order to identify the influence of higher education on green GDP, this paper first incorporates variables of higher education into the Solow model. Based on the human capital theory, economic development depends not only on the quantity of labor, but also on their quality. In this way, it is not enough to just include the number of human capitals, namely the variable L in the Solow model. The quality of labor should also be taken into account, which can be reflected by the overall educational level of a country.

The newly proposed form can be written as follows:

$$\mathrm{Y} = \mathrm{A}K^{\alpha}L^{\beta}E^{\gamma}. \tag{5}$$

Y here refers to either the traditional GDP, or the green GDP, and the independent variables K, L, and A respectively stand for capital, labor, and other factors in production. The variable E represents the quality of labor and its proxy variable in our research is the gross enrollment rate of higher education.

3.4. Modelling the Impact of Higher Education on Green GDP

The empirical analysis of our paper mainly consists of two parts. The goal of the first stage is to verify the first hypothesis mentioned above, i.e., whether higher education has positive influence on building green economies. We standardize the traditional and green GDP of countries and regions in our sample using the following equations.

$$\text{standardized GDP} = \frac{\log(GDP) - \overline{\log(GDP)}}{SD(\log(GDP))}, \tag{6}$$

$$\text{standardized green GDP} = \frac{\log(green\ GDP) - \overline{\log(green\ GDP)}}{SD(\log(green\ GDP))}. \tag{7}$$

The standardized GDP and green GDP are both lognormal distributed with a mean of 0 and variance of 1. The values of normalized GDP and green GDP represent the position of the original values in the overall distribution. In this way, the differences between the standardized green and traditional GDP can be a signal to determine whether the national economy is greener.

$$GAP = \text{standardized green GDP} - \text{standardized GDP} \tag{8}$$

If the difference, or the variable *GAP*, is positive, then the country's green GDP ranks higher in the overall distribution than the conventional GDP, indicating its national economy is green; otherwise, if *GAP* is negative, the nation's GDP outranks its green GDP, which means the corresponding economic growth is not so sustainable and environmentally friendly. Here, we build a general linear regression of *GAP* on higher education.

$$GAP = \pi_0 + \pi_1 * K + \pi_2 * L + \pi_3 * E \tag{9}$$

In the above equation, *GAP* serves as the dependent variable. The independent variables *K* and *L* represents capital and labor separately; while *E* stands for the gross enrollment rate of higher education, whose coefficient reveals the effect of higher education in the national green economic development.

The second part compares the contribution rates of higher education to the traditional and green GDP growth. By taking the logarithm on both sides of Equation (5), we build log–log models of green GDP as well as the traditional GDP.

$$\ln(\text{GDP}) = \ln(\text{A}) + \alpha_1 \ln(K) + \beta_1 \ln(L) + \gamma_1 \ln(E) \tag{10}$$

$$\ln(\text{Green GDP}) = \ln(\text{A}) + \alpha_2 \ln(K) + \beta_2 \ln(L) + \gamma_2 \ln(E) \tag{11}$$

After regressing the traditional GDP and green GDP separately on capital, labor and higher education, we plan to compare the parameters of these two models in order to explore differential impacts of factors pertaining to production on the green and traditional GDP. It should be noted that the output of these two models are both elasticity coefficients, measuring the percentage change in the traditional GDP and in the green GDP as a result of a percentage change in capital per capita, labor per capita, and enrollment rate of higher education, respectively. Given that elasticity is a dimensionless measure of the sensitivity or responsiveness of one variable to changes in another, the coefficients in the two models are easily interpreted and compared across categories.

4. Data and Empirical Results

4.1. Data Description

The data source of our study is mainly from the World Bank, and we particularly select variables including GDP per capita (constant 2010 US $) of different countries and regions, their total population, total capital (constant 2010 US $), labor population (total number), total enrollment rate of higher education, GDP generated by per unit energy consumption (constant 2011 PPP US $ per kg oil equivalent), and ratio of renewable energy.

We mainly choose relevant data during the period 1990–2015. This is driven by two reasons, the first is the United Nations Development Program had not started to collect data about the average years of schooling worldwide before the year 1990, and the second is that the statistics after the year 2015 have not been updated as of April 2019. Furthermore, we kept 187 countries and regions, which are among the 189 member states of the World Bank and also among the 193 member states in the United Nations. We excluded from our sample countries that deviate from general patterns of economic development, such as Kashmir and some post-war Middle Eastern countries. By doing this, we ensured our sample was representative, thereby improving the quality of our dataset in order to get more accurate results.

4.2. Comparison of Green GDP across Countries

Green GDP comes from and is tightly related to the traditional GDP; however, it serves as an irreplaceable measure for overall economic development different from the traditional indicator, because it takes into account the energy and environmental costs. As indicated in Table 1, we found that in 2014, there were wide gaps for different countries and regions after comparing their standardized GDP per capita with the standardized green GDP per capita. We chose the year 2014 because the data then were the most complete. It is evident that countries with higher green GDP per capita usually have highly developed tertiary industries, which consume few natural resources and do not cause much damage to the environment. For example, in Switzerland, whose green GDP ranked much higher than its traditional GDP (i.e., positive *GAP*), the financial industries, as well as other services, contribute to the vast majority of its GDP, while heavy industries and agriculture account for only a negligible share. By contrast, countries with negative *GAP* are often characterized by imbalanced industrial structures. For instance, the economic growth for nations in the former Soviet Union relies heavily on the energy-consuming and polluting industries, while those oil exporting countries like Iran are dependent on national natural resources. In fact, after comparing the *GAP* of the countries and regions, we learn that countries with outstanding performance in green GDP are not necessarily highly developed in economy and technology. Many newly emerging countries perform quite well with moderate economy scale and stable social development. In this way, whether a nation's economy is green is not merely determined by its power in economics, science, and technology, but relies more on its development pattern. For some nations that achieved industrialization earlier, economic stagnation refrained them from timely industrial restructuring and technological innovation, which, inevitably, set back their green economy development. On the other hand, the latecomers may have learned the lessons and benefited from current technological advances.

Table 1. Comparison of *GAP* across countries and regions.

	Standardized GDP Per Capita	Standardized Green GDP Per Capita	*GAP* (Per Capita)
Iran	0.11	−1.42	−1.53
Iraq	0.02	−1.17	−1.20
United Arab Emirates	1.39	−1.20	−2.59
Saudi Arabia	0.98	−3.17	−4.15
Ukraine	−0.32	−1.32	−1.00
Belarus	0.15	−0.33	−0.48
Russia	0.56	−0.47	−1.03
United States	1.57	0.94	−0.63
Germany	1.49	1.31	−0.18
Japan	1.51	0.86	−0.65
Switzerland	1.84	2.10	0.25
Denmark	1.68	2.02	0.34
Sweden	1.61	1.93	0.32
Norway	1.95	2.38	0.43
China	0.13	−0.09	−0.22

Note: *GAP* is an indicator to determine whether a nation's economy is green; *GAP* (per capita) equals standardized green GDP per capita minus standardized GDP per capita.

4.3. The Role of Higher Education to Green GDP

In order to examine the role of higher education, we performed the two-step analysis elaborated in the research design section. At the first stage, we ran the linear regression of Equation (9) based on the per capita data to verify the first hypothesis that higher education has positive influence on building green economies. The dependent variable in the model was *GAP* (the difference between standardized green GDP per capita and standardized GDP per capita), while the explanatory variables were capital per capita, labor per capita, and the gross enrollment rate of higher education. After checking with the Hausman test, we used the country fixed effect model with the panel data, and the regression results are shown in Table 2. The coefficient π_3 demonstrates the relationship between *GAP* and the gross enrollment rate of higher education. It is apparent that the enrollment rate of higher education had a statistically significant positive influence on the outcome *GAP*, indicating our first hypothesis to be valid.

Table 2. The linear regression of *GAP* on higher education.

	GAP
π_1 (Capital per capita)	9.11×10^{-6} *
	(4.38×10^{-6})
π_2 (Labor per capita)	−0.40 *
	(0.24)
π_3 (Gross enrollment rate of higher education)	5.26×10^{-3} ***
	(4.36×10^{-4})
_cons	-0.05
	(0.10)
N	2078
group	128

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

As for the second hypothesis that green GDP is more responsive to changes in higher education than the traditional GDP, we ran log–log regressions of Equations (10) and (11) separately at the per capita level. The variable higher education was still calculated by the gross enrollment rate of higher education. According to the regression results, a percentage increase in the enrollment rate of higher education can significantly lead to 0.2% of growth in GDP per capita, while green GDP per capita can significantly rise by 0.33% with one percentage increase in the enrollment rate of higher education.

Furthermore, the comparison of estimations from the two regression models (suest), combined with the chi-square tests, show that the coefficient of education in the green GDP model was significantly larger than that in the GDP model at the per capita level (Table 3). Considering that the regressions were modified from the Solow growth model, the coefficients can be interpreted in the same way. Therefore, we can conclude that green GDP is more sensitive to changes in higher education than the traditional GDP, which verifies the second hypothesis.

Table 3. The log–log regressions of gross domestic product (GDP) and Green GDP on higher education.

	GDP Per Capita	Green GDP Per Capita	SUEST
α (Capital per capita)	0.23 ***	0.42 ***	chi2 = 24.62
	(0.02)	(0.04)	Prob>chi2 = 0.0000
β (Labor per capita)	0.86 ***	1.66 ***	chi2 = 9.20
	(0.08)	(0.29)	Prob>chi2 = 0.0024
γ (Gross enrollment rate of higher education)	0.20 ***	0.33 ***	chi2 = 9.95
	(0.01)	(0.02)	Prob>chi2 = 0.0016
_cons	6.72 ***	11.36 ***	
	(0.08)	(0.19)	
N	2113	2113	
group	131	131	

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5. Discussion

5.1. Possible Mechanisms of Higher Education on Green Economic Development

This paper evidenced that higher education plays a significant role in developing a green economy. In order to better understand these underlying mechanisms, Figure 1 summarizes several possible channels of the corresponding impact. First of all, from the perspective of economic development itself, the human capital theory has brought education to the attention of economists and it has been unanimously recognized by academia that education can improve the total factor productivity and promote economic growth by enhancing the general quality of human capital. Institutions of higher education, undoubtedly, have been considered as cradles for top talents, which help to improve the labor quality by providing human capital to the economy.

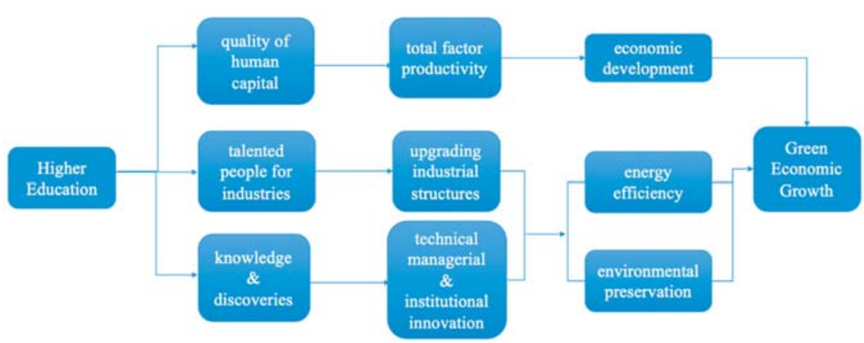

Figure 1. Mechanism of how higher education influence green GDP.

Apart from forming human capital, higher education also promotes economic development by accelerating industrial optimization and upgrading industries from labor-intensive to capital-intensive, and finally to knowledge- and technology-intensive [35]. A timely optimization of industrial structures is of great significance not only for economic progress, but also to ensure a smooth and sustainable operation of the green economy, during which nations can reduce their consumption of energy resources and control the costs in the environment. Indeed, among the many factors affecting industrial upgrading, well-educated workers with sufficient knowledge and skills who can adapt well to highly advanced technology-intensive industries make a fundamental and critical difference. Higher education, by engaging talented people who are in pursuit of knowledge and skills, is an essential prerequisite for industrial upgrading. In this way, higher education plays a leading role in the optimization of industrial structures so as to achieve sustainable economic growth.

Another possible channel is that higher education inspires individuals to acquire knowledge and open their minds in order to pioneer new discoveries and bring about technological, managerial and institutional innovations. These innovations lead to progressive methods of production for all walks of life and drive new demands for a larger size of the economy. Furthermore, these innovations streamline production processes to improve the efficiency of the green economy [36].

In this way, through three distinct channels—high-quality human capital, talented people for industries, and innovations in knowledge and technology—higher education is critical for green economic growth.

5.2. Implications for Sustainable Development: Taking China as An Example

Higher education not only contributes greatly to expanding the size of economies, but more importantly, it helps to promote economic growth in a more environmentally friendly way. This is particularly meaningful for countries facing challenges in sustainable development. The context in China, whose development path was found problematic and not sustainable, has been discussed in our research as a typical example.

Over the past four decades since the reform and opening up, China has maintained a high economic growth rate, which can be attributed to either the institutional reform or the large population. However, it has been in a precarious situation considering the serious environmental pollution, waste of resources, and the aging of population, etc. Fortunately, the Chinese economy has started to pay attention to the sustainability of its economic growth, not just striving for higher productivity. The society now stipulates that people should seek comprehensive development instead of simple growth in GDP, aiming at sustainable growth in a socialist market economy. With this principle, its development path has been adjusted from three dimensions, the first and most obvious of which is to slow down the growth rate and develop at a modest pace. At the same time, it emphasizes continuous optimization and upgrading of industrial structures. Another noticeable characteristic is to shift the driving force from factor- and investment-driven to innovation-driven. Data of China's first three quarters in 2018 depicted a better economy with higher quality and more optimized structures. Specifically, consumption contributed more to economic growth than investment, service sector grew faster than the secondary sector with high-tech industries and equipment manufacturing standing out, and energy consumed by per unit of GDP declined noticeably. China's tertiary sector has contributed substantially to the economic growth, accounting for more than half of the total industries (Figure 2), and its proportion is predicted to increase steadily in the future. Overall, China has grown from a large agricultural country to a world factory, after which it has developed as a technologically innovative economy by creating wealth through science, technology, and culture.

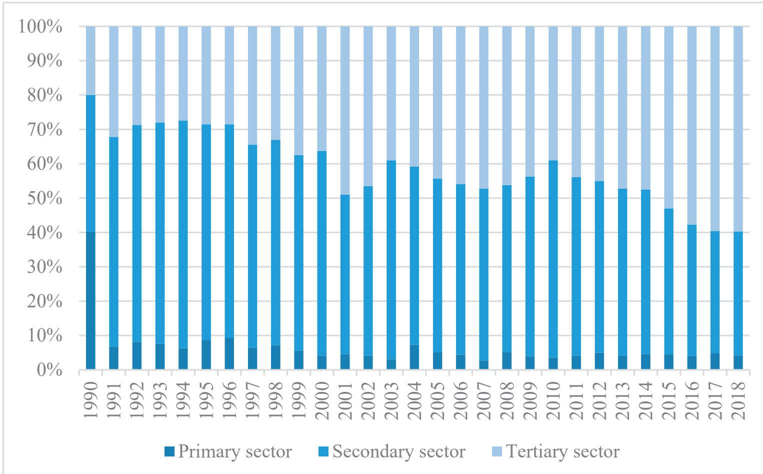

Figure 2. Changes of Chinese industrial structures.

As for the educational investment in China, before the year 2000, its educational expenditures were less than 2% of GDP, which was much lower than the average level worldwide, not to mention in comparison with the spending in developed countries. However, China's current investment in education has increased to more than 4% for six consecutive years, of which expenditures in higher education constituted about 1.4%, equivalent to most developed countries. This, with no doubt, is a positive signal for China's future development. By transforming the advantage of a large population in China into the feature of high-quality talents, higher education will definitely play a crucial role in China's sustainable development in the future.

6. Conclusions

This paper explores the impact of higher education on the development of a green economy. By proposing a new approach to indirectly estimate green GDP, two hypotheses have been confirmed through empirical analysis.

First, higher education plays a significant role in building a green economy.

Second, green GDP is more responsive to changes in higher education than the traditional GDP.

This paper highlights the importance of higher education in the sustainability of development. The quantity of labor has a weakening impact on green GDP, while the quality of labor represented by education has exerted a more pronouncing influence on green economies. This implies that economic development starts to rely less on the number of labors in the workforce and become more dependent on higher education, which not only provides elements for production, but also effectively improves industrial structures and increases production efficiency.

There were two limitations of our studies. First, we have indirectly estimated green GDP by creating a new indicator, though the absolute value of this indicator cannot stand for the real green output. In spite of our meaningful exploration in the calculation of green GDP, further analysis and discussion about relevant indicators are still needed in order to establish the reliability and validity, considering the complexity in calculating environmental pollution and the unavailability of data about resource consumption when estimating green GDP. Second, we have proposed one possible interpretation of the influencing mechanism of higher education on green GDP based on current knowledge and speculation, and the effectiveness of this interpretation still needs to be evidenced by empirical studies in the future.

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Co-Creation for Social Innovation in the Ecosystem Context: The Role of Higher Educational Institutions

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Abstract: This study examined the role of Higher Educational Institutions (HEIs) in promoting, creating, and sustaining social innovation. Recently, HEIs have extended their contribution beyond the traditional function of teaching and research to perform in socio-economic problem-solving. Considering the increasing trends of higher education involvement in social innovation practices, this study tries to examine the tools such as learning processes and systemic thinking approach that could be helpful to align the function and responsibilities of HEIs towards social innovation. The objective is to develop a theoretical understanding of the "co-creation for social innovation" concept and to understand the functions and activities of HEIs that can contribute to this process. To promote co-creation for social innovation, HEIs should actively encourage collaborative learning tools that focus on open platforms for collective action and systemic change that help them to engage with society and strengthen their collaboration with social actors. Different activities such as mutual learning and knowledge diffusion using a transdisciplinary approach, technology-based learning and collaboration, and relational transformation are key enablers that can promote social innovation.

Keywords: problem-solving; critical reflection; knowledge integration; social learning; systemic thinking

1. Introduction

There has been an increasing interest in understanding and expanding the role of Higher educational institutions (HEIs) for social innovation to address complex societal challenges [1,2]. Recently, social innovation, emerged as one of the top institutional agendas in European Union (EU) policy process and appeared in various EU strategies such as relaunched Libson Strategy and Europe 2020 strategy [3]. The growing trends of social innovation initiatives in the international arena have made the topic highly important. However, the key issue for social innovation in HEIs is to integrate social innovation in the function and working model of HEIs. The rigid institutional environment and lack of flexibility to adapt as per the changing social context have reduced the effectiveness of HEIs in social innovation initiatives. To improve the efficiency and effectiveness, HEIs require a more flexible environment where they can transform to improve the attributes and functions and to work more responsible towards society. Currently, HEIs are facing immense pressure to continuously enhanced their role with the fast-changing society to cope with the changing complexity of the enivironment and to respond to the changing social needs. Most of the existing literature on the changing role of HEIs in society highlights the economic contribution and wealth creation perspective of HEIs, where they perform various market-oriented activities such as technology transfer and creation of knowledge-based enterprises through spin-off that promotes economic growth and regional development [1,4]. The current entrepreneurial model and third mission focuses on active university-industry participation and technology commercialization activities are mainly limited to their economic role in society [4,5]. However, these studies have undervalued the societal engagement of HEIs where they serve as a primary role in bringing social change and shaping the culture and values for future society [5]. The new role of HEIs in social value creation can only be achieved when societal needs can be integrated into HEI activities, and knowledge generated can be used to solve real-life societal challenges. To manage the prevailing challenges and to improve the engagement of HEIs in social innovation practices require an understanding of an integrated approach that leads towards the redesigning and transformation in different levels of processes and functions of HEIs that can improve their capacity for social innovation [6].

Considering the institutional theory perspective, Cai and Liu [7] explored the role of the university as an institutional entrepreneur [7] and highlights actor-driven activities of the university to show how changing the institutional conditions helps the university to improve their performance and to foster regional innovation [5,7,8]. The concept of an institutional entrepreneur focuses on the role of HEIs as a change agent which participates in the designing of a particular institutional arrangement through involving different strategies (organizing sufficient resources and mobilizing resources and power) to enact the institutional changes [7–9], and the new role makes HEIs more socially responsible. Merton et al. [10] examined the impact of changing of curriculum (in two US universities) and found that implementation of changed learning processes and curriculum was influenced by how well the changes in learning processes are associated with the arrangements and culture of the institutions, which directly have an impact on the success of innovation [10,11]. In another study on educational system transformation, Furst-Bowe [12] strongly suggests the need for a system thinking approach for changing the HEIs' educational programs, learning processes, strategy, and management [12]. The study emphasized when the innovation leaders, administrators, and researchers use a system thinking approach in governing and transforming institutions; the system thinking improves the pace and efficiency of working.

In order to create successful innovation, HEIs depend on its social networking capabilities such as how they collect resources, facilitate the knowledge dissemination process, and identify opportunities by forming social ties [11,13], thus increasing legitimacy for collective action and social innovation process. Social innovation in HEIs usually comes as a consequence of collective action and collaboration with institutional actors of the innovation ecosystem [14,15], low level of collaboration reduce the chances of co-development and co-creation of social innovation (CoSoI). Thus, it is important to understand the ways by which HEIs can enhance their networking capabilities to facilitate co-creation of social innovation.

To fill the gap between the current capabilities and status of HEIs and in order to fulfill emerging goals of changing society, it is important to examine the changes to improve the capabilities of HEIs to create and facilitate social innovation. Thus, the paper aims to develop understanding by examining and exploring different ways by which HEIs can improve their capabilities and capacity to enhance the opportunities for social innovation learners to participate in social innovation practices. This aspect focuses on two sub-questions: 1. How HEIs can incorporate different levels of changes to re-establish and reorganize their processes, activities and institutional action plan to improve their capacity and capabilities? The second question is 2. How these changes are aligned with the role of HEIs to bring social change and transform society. The paper further aims to find out how innovation in learning processes and the systemic thinking approach can support and encourage the participation of HEIs in CoSoI process? This question considers role of HEIs in the innovation ecosystem to facilitate CoSoI which depends on networking and formation of social capital aspects.

Considering the various efforts to improve the capacity and to enhance the role of HEIs in innovation process, this paper proposes a framework how the changes in the learning models, improvements in curriculum programs, and the use of systems thinking approach can be linked with the contribution of HEIs in the social innovation process. This paper is structured as follows: Section 2 highlights the social innovation concept and outlines the steps required in co-creation for social innovation. Section 3 presents research methods and process. Section 4 elaborates about developing CoSoI capabilities through learning and system thinking approach. In Section 5, we discuss the transformations in the educational system. Section 6 presents proposition and recommended action plan and lastly, discussion and conclusion are presented in Section 7.

2. Literature Review

2.1. Social Innovation as an Emerging Context

Nowadays, society is facing new problems and grand challenges (environment destruction, social exclusion, aging, energy security, etc.), which are complex, interconnected, and multidisciplinary in nature and almost impossible to solve without the active and direct participation of actors of society and citizens. The complex interconnectivity of the problems has driven society towards social innovation initiatives that require critical thinking and cooperation that can guide the co-creation of new ideas or solutions to provide sustainability in society. According to The Bureau of European Policy Advisors (BEPA), social innovation is social in its means and ends which provide collective empowerment to people, meet their social needs, and drive social change [16]. Recently, social innovation has been increasingly evident in policy areas and projects of development organizations as a means to solve emerging societal problems. However, the idea and the notion of social innovation is still weakly conceptualized due to various definitions and lack of comprehensive theoretical foundation [17–21]. These definitions (Table 1) indicate the involvement of social aspects as an important feature and the innovation process is often bottom-up and context-specific approach [14]. Mulgan et al. [20] pointed out that working on social innovation depends on meeting the effective demands and supply together the idea production and diffusion of knowledge require proper strategies and adaptation to support the combination of demands and supply to achieve social impact [20]. Moulaert [22] conceptualizes social innovation as an outcome of actions which should lead to an effective way to bring improvements in social structure and relationship, and also can bring empowerment in society [14,22]. The new ideas that emerge as a consequence of social innovation provide an effective way to meet social goals by affecting (creating new or altering existing) relationships among the engaged stakeholders [23–25]. The improved or new relations in the social innovation process are based on trust and understanding rather than status and position and create a supportive environment that challenges and replaces the dominant power structure and institutions [26]. Thus, the key aspects of social innovation are:

- learning and knowledge exchange process,
- collaboration and change in relation,
- major actors and organizations involved in the process,
- change in social interaction and relations, encompass new ways of knowing and doing,
- collective empowerment and social change,
- development of new ideas and action to meet the demands,
- effective solution to address societal problems,
- sustainability to the outcome.

Table 1. Definition and stages model of the social innovation process.

Authors	Stage1	Stage 2
Mulgan et al. 2007 [21]	development of new ideas or activities or new approaches	to meet societal goals
Herrera 2015 [27]	measurable initiatives	generate social value
Jørgensen 2018 [28]	design co-creation system changing	alters the perception, behavior and social structures
Phillis et al. 2008 [19]	novel solution value generation	an effective and sustainable solution to society
Pol and Ville 2009 [29]	new ideas	quality and quantity of life
Moulaert 2013 [22]	outcome of actions	empowerment
Bureau of European Policy Advisors (BEPA) 2010 [16]	innovation social to their means and ends	empowering people and drive social change

2.2. Ecosystem Concept of Social Innovation

The ecosystem of social innovation allows the facilitation of a network of actors that interact and inter-relate in a variety of forms to co-create social innovation [30–33]. The ecosystem structure is dynamic and not limited to any geographical or industrial boundary and can evolve at any level in response to the actor's interaction to co-produce innovation. In these ways, it is unlike the system organization, which is static and geographically bounded. The collaborative structure of the ecosystem has agility in the environment and because of this ability of the actors to enjoy self-sustaining governance networks [34]. The social innovation ecosystem is characterized by complex interactions among a variety of stakeholders (actors) and their components, and the ecosystem aims to support technology development and innovation [35]. Multi actor perspective of the ecosystem and their connection helps to develop new ideas and solve societal problems. In the recent setting, the process of innovation is no longer seen as linear but as the unforeseeable product that a system generates by a nonlinear iterative process and increasingly relies on interaction and integration among the actors in the network [36,37]. The ecosystem concept provides a complete framework for socio-economic development, in which actors with diverse backgrounds and perspectives collectively work to improve the environment to make it favorable to innovation [38–41].

The framework of the innovation ecosystem is predominantly suitable for the creation of social innovation, where innovation follows a bottom-up approach that embraces the inclusion of society [42,43]. In the context, actors and supporters of the ecosystem must leverage the multifaceted system of interaction in rapidly changing environments. Moreover, the components of the system like policies, governance, financial, and social structure should create an environment and culture to support the system. HEIs play an important role in promoting the culture of trust and learning that reduces the conflict between partners. The knowledge exchange between HEIs and the community in the ecosystem brings positive change in society and promotes social innovation.

2.3. The Context of Co-Creation for Social Innovation

The co-creation is an important factor in the development of social innovation in the ecosystem framework which promotes the complex interaction of actors and citizens in the creation of new ideas. Co-creation is the core of the social innovation process encourages actors to integrate knowledge and assets, which can provide long-term benefits to society [44–46]. The idea of co-creation came from the business-and-service economy, in which co-creation is referred to the participation of the end-user with the business firms or service providers to co-create value (customers in service-dominant (S-D) logic), and the process is considered very cost-effective and time-saving [47,48]. S-D logic proposes that co-creation is a co-operative and dynamic process that involves the consumers in value creation. However, the concept of co-creation has not been widely explored in knowledge and innovation areas where it can be implied from the ecosystem perspective and can allow various actors to participate in innovation creation to co-create innovation. In a social-innovation context, the complex societal challenges demand the integration of knowledge and ideas and the collective approach of various innovation actors. Moreover, resources and capabilities (human and financial resources; knowledge, empowerment) are limited in individual organizations, so co-creation is a prerequisite for social innovation. EU Social Innovation–Driving Force of Social Change (SI-Drive) projects consider around 1005 cases in social innovation confirmed that co-creation and empowerment are two general features of all sorts of social innovation [46]. The means of collaboration, co-creation, and power shift during resource integration primarily determines the modes and approaches of social innovation.

The co-creation in the social domain involves citizens and civil society in designing and implementing the process in society. Voorberg, Bekkers, and Tummers [23] developed a framework of how citizens could be involved in the various co-creation process; citizens act as the initiator (co-initiate), as a co-designer and as implementors (implement public services). In the majority of cases, citizens participate in the co-implementation process, and the involvement of citizens in any of the co-creation process produces valuable outcomes [45]. To understand the co-creation for social innovation, we adopted Young Foundation principles and processes which serve as a foundation for CoSoI [49]. The principles and processes are based on the social innovation community (SIC) experimentation projects that aim to create a supportive environment for social innovation in Europe and beyond [49]. The four phases of co-creation of social innovation can be described as:

1. Prepare—understanding of challenges and problems and provide time to think about all possible solutions, team building, and capacity building),
2. Co-define—define the challenges, engagement of new stakeholders, co-defining the process),
3. Co-create—connect with similar challenges, resources for pilot work, a collective creation of solutions,
4. Implement—application and testing of the solution.

Based on the co-creation process stated above, we developed the CoSoI process to better understand the concept in the social innovation area. CoSoI can be broadly understood as a four-stage process (Figure 1). The first step of the process is to identify the societal needs, demands, and challenges which is important to define the existing problems. This stage is the same as the preparation phase main aim is to develop capacity and core team. The second step is to recognize the resource capabilities of different actors and to map stakeholders. This step is about co-defining the challenges that use a collaborative and open approach to better frame the challenges. For example, the SIC project identified and defined many local and complex challenges of Europe related to urban redevelopment, immigrant and refugee integration, public health, etc. and shared different ideas and solutions to solve these problems [49]. The third step explores knowledge diffusion, mutual learning, and resource integration activities and is identical to the co-create phase which focuses on the collective creation of solutions. In the fourth step, actors jointly utilize and exploit the knowledge and resources to create novel ideas and put those ideas into action. The implementation phase is related to the practical application of ideas to test the solution. In all steps, active and real participation of the community with key authorities at the local level is an important key for the successful social innovation process [50].

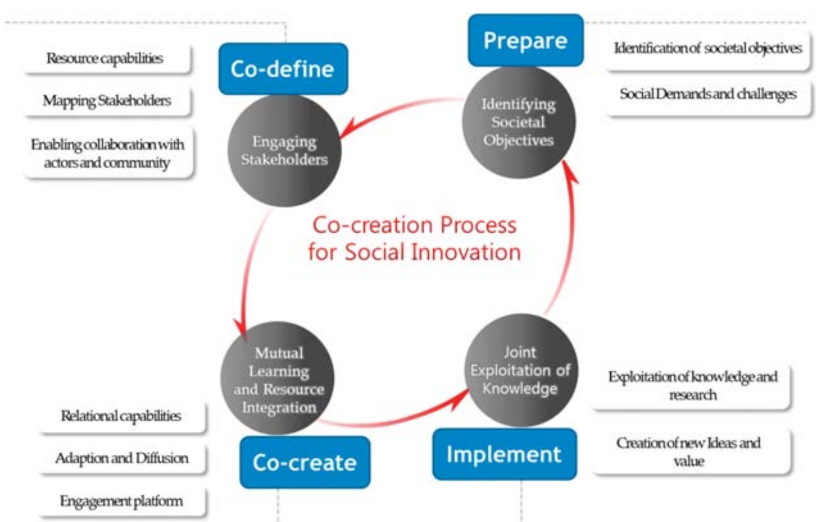

Figure 1. Four stages of Co-Creation for the Social Innovation Process. Source: adapted from the Young Foundation [49].

Co-creation activities among actors rely on the resource capabilities of other actors; the networking and relationships between embedded actors determine the diffusion of knowledge, and integration of resources [51]. Moreover, relational capabilities to interact with external partners transform the social relations by redistributing resources and power among the actors. An actor with superior relational capabilities can interact better than other actors with partners, and thus has superior access to knowledge and resources, and can thus enhance the co-creation process. This diffusion of knowledge and research by integration and transformation of social relations, governance, and power structure are the basic components of social innovation [52], and the process presents a new solution to attain sustainability in society [53].

3. Research Method and Process

The main purpose of the research is to find the way through which HEIs can participate in co-creation of the social innovation process. For the study, we used the Web of Science (WoS) core collection database to extract the documents. The search was conducted using the keyword: "social innovation" and "higher education" or "university in the title, abstract or keywords (TS = Topic) to find the relevant articles. As a result of the search, we found 67 publication documents. Out of 67 documents, only 41 publications were available in English. In the next stage, we checked for duplicate articles and also did a manual screening of title and abstract of these 41 documents to find the relevance as our search criteria; we excluded two articles as duplicates. Furthermore, after the manual screening of title and abstract, we removed nine records that were either not related to higher education or does not discuss the concept of social innovation in education perspective. Finally, we downloaded 30 articles for our systemic review. We checked key concepts and research trends used in these studies by analyzing the author's keyword (Appendix A). Finally, these 30 publications were selected for the literature survey and were used to build a model for HEIs to participate in social innovation. In addition to the above documents, we also reviewed the European Union social innovation project reports to gain better insight into the topic.

3.1. Framework for HEIs to Participate in CoSoI

The engagement of HEIs in the social innovation process is challenging for several reasons. First, HEI is considered as a change-resistant organization [54]. The institutional culture, legacy, and bureaucratic environment slow down evolution and make them resist change. Second, since social innovation has no clear standard definition, the concept uses a broad variety of expressions and approaches. Third, in the context of HEI contribution to social innovation, there is no specific framework and guidelines on how HEIs should contribute to the social innovation process. Benneworth [55] found HEIs' emphasis on teaching and research activities over place-based innovation that confines their role in dealing with social innovation. The restrictions and challenges in institutional structure and function create a gap in the pathway of HEIs for successful implementation of social innovation; HEIs, therefore, require proper planning, strategies, and evolution to be involved in the process of social innovation.

HEI evolution for the social innovation process has been investigated under two conventional bodies in the literature. One focuses on the process of institutional adaptation of HEIs towards changing environmental challenges [56] and the other emphasizes the internal characters of HEIs [57]. The literature covers both external (system) and internal (institutional) structures and function of HEIs that affects their capability to innovate and to serve the societal challenges and describes multiple level change in the structure and function of HEIs that include the change in structure, governance, and educational curriculum [58], change in norms and values of the institution [41,59], and changes that would improve the quality of interaction and collaboration. With the systemic review process, we identified some useful theories and concepts that could be helpful for HEIs to initiate necessary changes and to improve their participation in social innovation. We suggest internal (institutional) and external (ecosystem) level changes are needed in HEIs to facilitate the social innovation process as shown in the framework (Figure 2).

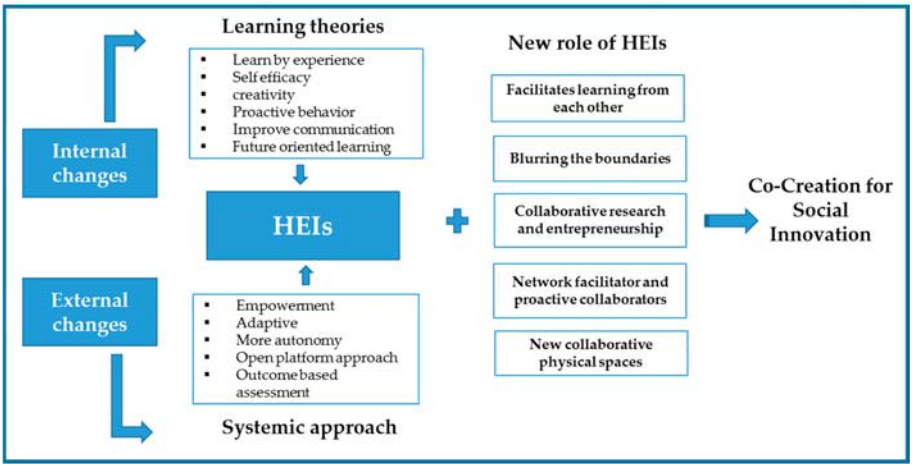

Figure 2. Framework model for HEIs in CoSoI.

The institutional changes can be explained under the institutional entrepreneurship theory that explores the role of HEIs as a change agent who supports the factors and environments necessary to initiate such changes and actively participate in implementing those changes. Changes in institutional setting reinforce the innovation in teaching and research practices to increase the participation of learners in social innovation initiatives. Similarly, system change theory focuses on the understanding of the organization as a system and focus on the interconnectedness of components which enhances the working efficiency. Whether these changes are made at an institutional or system level, such changes are mostly influenced by the decision of key individual actors, academic leaders, or department leaders who play an important role in the development of the innovation process. These people play a crucial role as a social innovation leader in various social innovation projects. In many cases, deans of universities were found to play a key role in driving innovation [60]. In other cases, the head of a department, teachers, researchers, and students can have a leading role who create and run new social enterprises by spin-offs. In ecosystem environments, there can be the other key actors outside the academic settings, local government leaders, bureaucrats, and business professionals can be included as innovation leaders as per their ability to create a new vision, the power to influence the decision and practical capabilities to lead the projects and to make innovation happens.

Many HEIs have developed these changes through innovating the learning environment and introducing new approaches that help learners to gain knowledge and skills necessary to facilitate social innovation. The OECD, Centre for Educational Research and Innovation (CERI) report [61] discussed various ways by which HEIs can engage with society. HEIs can become involved with citizens to help them to define and analyze their problems and can provide knowledge, consultancy, resources, physical spaces, and financial support to the community to assist in societal development. Social innovation and sustainability mission is strongly incorporated in many universities of South America and Europe which improves the contributions of these universities in tackling societal challenges [62]. The involvement of HEIs in CoSoI requires a reassessment of the organizational system and reconsidering our approach towards new knowledge processing that can bring innovation. Higher education, therefore, needs to extend its scope in facilitating new learning processes and experience that requires a disruptive innovation model to facilitate these changes.

3.1.1. Embedding Social Innovation in Education (Learning Theories)

To facilitate CoSoI, it is important to consider the learning methods that can develop new skills and the capacity to bring transformation and behavior modification to social innovation. The designing of learning processes could be used as an effective strategy for organizational development as well as to develop an interaction between HEIs to external actors [63]. Here, we identified the various learning processes from our systemic literature review on WoS data that can help to stimulate the process; Alden Rivers, Nie, and Armellini [64] identified the importance of different skills, behavior associated with the notion of changemaker and argued that designing education model for social innovation should be based on the understanding of outcome of the designed approach and the adoption of pedagogical praxis that supports and facilitates the designing and learning process [64,65]. The study conceptualized the different conception of changemaker (AshokaU) to develop the related skills, behavior, and attributes across the disciplines at the University of Northampton. The five different conceptions were found under changemaker concepts, for using this concept (1) as university strategy, (2) as critical thinking and problem solving approach, (3) for enhancing employability, (4) for social betterment, and (5) for personal transformation. These conceptions provide the basis to formulate a strategy for change in attributes and behavior for CoSoI.

The different learning processes such as transformative learning [66–68], (emphasizes on change in thoughts, perceptions, and actions through critical reflection), social learning (focuses on the learning through social interaction and participation), and critical learning [69] (learning process that opens up a new lens of perception based on critical reflection developed through social contextual experiences) are essential for developing competence to understand the context and co-operate with a variety of partners involved in the innovation process. Mezirow [67] recognized that transformative learning involves an important aspect of learning in adulthood which provides adults with a new point of view to see the world as a result of the perception of their own past experiences [67]; the adult learning is largely understood as a means of improvement of the well-being of society [70]. The knowledge and reflection achieved from experiences can help to develop analytical capabilities to deal with future societal challenges.

The learning process is important for the development of social and practical skills that are an opportunity to recognize and articulate the underlying theories and assumptions in their current practical approach, and could lead to a better understanding of problems. The outcome-based learning approach provides a way for assessment and developing the praxis to keep a balance between theoretical and practical approaches. Designing a social learning approach in the educational curriculum helps learners to change their attitudes and behavior towards societal problems and support them in creating social innovation [54,71]. This learning process focuses on the transformation of cognitive structure and behavior for human development and can develop a more shared knowledge between the partners. Critical reflection is a key mechanism of the learning that could be useful to place-based learning experiences and learning through social interaction which are considered as crucial components to the transformative capacity of HEIs for social innovation [63,65]. These learning processes could deliver new ideas through shared understanding.

This project-based learning process involves principles and approaches of action learning where a learner involves the creation of knowledge by collective activity and develops the solution by working on the real problems [72]. This process of learning by doing is a critical and holistic approach to traditional theory-based teaching. These learning processes involve the rigorous approach of developing the solution by understanding the context and relations and by taking action on the idea and then reassessing and refining the methods [73]. Similarly, introducing the analytical research practices such as action based research (defined as research methods that helps to systematically analyze the problems and help to develop practical solutions to address those problems quickly and efficiently) is seen as beneficial for the CoSoI process. Hence, this process helps to develop visions that can attain complex challenges and lead pathways to sustainable solutions.

The key elements of transformative learning as defined by Taylor [68]:

1. Focus on individual own experience as the main source for transformation,
2. Critical reflection,
3. Understanding of context,

4. Valuing social relation,
5. Communication with the self and with others,
6. Future-oriented and holistic approach.

The adoption of novel learning processes by HEIs is critical for the institutional environment. These learning processes allow students and academicians (or learners) to participate in real-life challenges and prepare them to think critically (or search for) innovative ideas [74], and at the same time make them responsive to the solutions. Learning at a collective level through shared understanding and actions provides an opportunity to engage in more analytical discussion and approach societal issues [75]. At the institutional level, these learning processes provide a strong environment and mechanism to HEIs to expand their internal capacity and help them to build a relationship with external partners. HEIs require a value-based strategy that can guide their learning and teaching to bring institutional change and can enhance their impact on society. HEIs mission should reflect the purpose and value of the organization. The use of learning processes as a pedagogical strategy could provide empowerment and can drive social change.

In addition to innovation in learning processes, HEIs introduce different innovative and entrepreurship programs in curricula that provide opportunities to students and academicians to participate in various entrepreneurial activities and teach them with skills and knowledge to come up with novel business ideas and solutions. Such entrepreneurial ideas have supported many new social and business ventures and creation of new start-ups. Entrepreneurial experience nutures students with confidence and risk taking abilities and prepares them to better participate in addressing grand social challenges through social entrepreurship.

3.1.2. Systemic Thinking Perspective for Organizational Change and for Strengthening the Collaboration

In the ecosystem context, HEIs have been considered as a key organization in bringing social change and development by improving the organizational effectiveness and by strengthening the interaction and collaboration with other stakeholders. We reviewed and elaborated on the system thinking concepts and approach as a pedagogical framework [76] to highlight the characters that could be applied for the improvement of higher education institutions in the co-creation of the social innovation process. The system thinking approach provides a holistic understanding of the system as a whole and provides the ability to identify the components of a system, their processes, and interconnectedness within the system [77]. Bertalanffy [77] was the pioneer on system thinking, explains the approaches of viewing the problem as a whole, and emphasizes more on the interrelation of the components of a system rather than components itself [78]. Seddon [78] compared a traditional management approach (command and control) with a systemic thinking approach in managing the business and public services and believes that a systemic approach would lead to optimization within a system and provide benefits like lower cost, high efficiency, and better service quality as compared to a command and control management approach. The basic underlying concept of systemic thinking is adopted and compared with the approach with traditional educational organizations and functions (Table 2). In HEIs, systemic thinking can help students to visualize them as part of a large system and provide a better understanding of how-to bring changes to improve effectiveness in the institution and their co-related actions. Applying the systemic approach is also useful to bring complex and apparently disparate issues together and provide an understanding of every aspect of the issue and their impact on a variety of domains [79]. Thus, this systemic approach can help students to develop and implement solutions.

The use of a system thinking approach in recognizing the context and interrelationship among actors can guide to a framework that can enhance their behavior in the CoSoI process [80]. Fullan [81] emphasized that most of the HEIs fail in innovation as they have not understood how to develop system thinking in action. The incorporation of a system thinking approach in teaching and learning facilitates innovation as this approach involves activities such as brainstorming models, shared vision, and learning in the team. A systemic thinking approach produces strategies and environments that nurture learning (mutual learning, situational learning, learning as a perception), effective communication and encourages collaboration; all these components are desirable to improve the performance in CoSoI [82]. Dhukaram et al. [83] urged that the use of technology and ICT for learning and training in the system can be useful for developing solutions to complex problems in less time. Moreover, in many universities, a systemic approach is used to design technical and engineering education that involves an outcomes-based approach to curriculum development, and the assessment and evaluation process based on results [84] can improve the innovative capacity. The systemic thinking approach allows HEIs to make changes on various components (multilayer transition) of education system including a change in hardware (computers, equipment, and devices), software (operating system and other software), role changing (bottom-up approach, student role in project-based learning), services, finance, management, and process change, regulations and law, etc. [83]. The systemic thinking approach is particularly beneficial to address wicked problems and grand challenges of the 21st century that require a variety of actors and the use of systemic perspective involved towards practical, social-based learning and adaptive approach. Thus, the systemic thinking approach can be very useful to improve HEIs capacity in bringing societal transformation and development.

Table 2. Comparison between the traditional approach and the system thinking approach.

	Traditional Approach	System Thinking Approach
Outlook	Top-down (focus on to officers' perspective)	Bottom-up (focus on user), Outside-In
Decision making	Isolated, No integration with work	Integrated with work, Work-based learning
Assessment Methods	Traditional Assessment	Outcome-based and Project-based assessment
Motivation	Obligatory, Extrinsic motivation	Intrinsic motivation
Methods of teaching and learning	Closed; Within the organization	Open platform, Based on co-operation and partnership, social learning
Management approach	Change resistant	Adaptative management

Source: Created by author, Adapted from [78].

4. Developing CoSoI Capabilities through a Learning and Systemic Thinking Approach

The use of learning processes and a systemic thinking approach in HEIs requires re-evaluation and revision of knowledge creation and a dissemination approach that can increase their contribution to CoSoI [85,86]. Learning and systemic adaptation involve various mechanisms through which HEIs can improve the capacity and capabilities of co-creation for social innovation. The co-creation aspects focus on collaboration and social interaction which can bring integration of knowledge/experiences and resources. The learning and systemic thinking process involves various activities such as knowledge sharing, collective research, and experimentation and critical thinking and reflexivity which transform the capacity of HEIs towards CoSoI [63,86]. These processes reshape the structure and relationship which involves a change in the power structure and redefine the collective meaning, which finally results in a change in attitudes, behavior, knowledge, and skills. Social learning and a project-based learning approach in teaching and curricula are used to develop critical thinking, independent problem-solving skills as well as working in a team. Furthermore, the systemic approach allows the development of multiple viewpoints to understand a problem and provide a holistic approach to decision-making.

4.1. Knowledge Sharing and Collective Experimentation

Knowledge sharing and experimentation in a social context is the most prominent way through which HEIs participate in social innovation activities. The literature review highlights the benefits of a collective approach to learning and experimentation which facilitates knowledge sharing and diffusion within and across the networking platform [87]. HEIs can extend their scope of knowledge production to a collaborative learning platform which is important to prepare learners as critical thinkers. The new learning processes such as project-based learning encourage learners to learn while doing and experimenting to develop their capabilities [88]. Collaboration, critical reflection, and creative thinking are a few key components of learning that can foster knowledge exchange activities between partners and play an important role in empowering society. During the process, social innovation learners learn from their own past experience of success or failure and alter or redesign the alternatives to get the desired action [63]. Networking and collaboration formed through the social learning process form a sustained interaction among actors to work together in order to find solutions to shared problems.

In addition, the incorporation of learning methods (social learning, learning by doing) as a teaching strategy to teach students to value social relationships and changes their ways of managing, doing, and seeing things. The new perspective encourages their capacity to understand and co-operate with a wide variety of actors as collaboration based on social relation provides a more effective problem-solving approach than communication as it provides a mutually accepted solution that is sustainable. The knowledge spillover effects stimulate technology innovation and have a positive impact on local communities. Furthermore, the exploitation of knowledge outside the academic setting in an open environment increases the possibilities to solve real-world problems and encourage social innovation practices [87,88].

4.2. Transforming Capabilities

Creating new and innovative capabilities is another way through which learning processes support the co-creation of social innovation activities. According to Ottaviano [89], capabilities refer to abilities to use the processes (business) in order to mobilize its resources and to attain the desired innovation outcome. Capabilities can be a collection of learning capabilities (knowledge, skills, competency), technological, financial, social, and organizational capabilities towards the innovation goals. For example, technological capabilities such as abilities to produce novel ideas and develop the idea into products are key to innovation [90]. Compared to technology and product innovation, social innovation focuses on transformative skills and empowerment in order to find solutions for social challenges and demands. HEIs use various strategies and processes to manage organizational effectiveness and to improve institutional capabilities that focus more on creating public values instead of economic benefits and providing fertile ground for CoSoI. Learning theories and system thinking approaches create new capabilities and improve the existing ones that allow HEIs to adapt to the changing environment, and simultaneously facilitates social innovation [91]. Moreover, improvement in the capabilities of HEIs provides a better understanding of the process and supports the integration of new practices in the education system to deliver social change and facilitate CoSoI. Thus, it is believed that the improvement in HEIs capabilities is positively related to the co-creation of social innovation.

4.3. Evaluating and Reflecting

Critical reflection and evaluation are an important part of social innovation learning processes. Actors not only learn from the past reflection but evaluate the experiences to formulate better strategies. The critical reflection process identifies the deep-rooted assumption about society and individual relationships with society and brings cognitive changes. The alteration in underlying attitudes and beliefs and improves their thinking process to innovate and value social relations. The evaluating and reflecting process further influences the dominance and leadership structure of institutions. The new leadership structure based on trust and mutual relations in social context improves the transformative capacity for social change and promotes CoSoI in the long run. The learning processes further encourage the distribution of responsibilities between the actors and disperse the leadership from dominance organization to multiple organizations. This perspective helps to reduce the cognitive gap among engaged partners and support the continuous exchange of ideas and value [92]. Thus, it is important to support critical reflection and encourage evaluation through learning and systemic thinking approaches that can lead to transformation at different levels and can enact a collaborative approach to bring more desirable solutions for the society.

5. Transformation in an Educational System

These learning processes and systemic approaches bring transformation in the educational system and institutions where HEIs can use them to create public value. These approaches can change future perspectives and will promote new models in education and research that are based on:

1. Interdisciplinary research and new learning models,
2. Action-based research and entrepreneurship education,
3. New collaborative physical spaces.

5.1. Interdisciplinary Research and New Learning Models

The emergence of new courses and interdisciplinary research fields in learning processes and curricula have blurred the boundaries between disciplines. The introduction of new technology and research areas (biotechnology, nanotechnology, robotic technology, and other digital technologies) have also blurred the borders between basic science and applied research field [93–95], as these interdisciplinary technology fields require collaborative approaches between both science and engineering disciplines [96], and are useful to tackle complex problems of society. The convergences of different areas have an important implication on society and entail a learning approach that requires contribution and collaboration among different actors. The new fields educate on interdisciplinary thinking and skills to provide a better understanding of disciplinary methods across the fields to foster innovation. The new variety of interdisciplinary research areas provides the ability to think beyond the boundaries of a particular discipline, and encourages innovative culture and values co-creation. The technology areas also suggest an integrative approach and provide innovative solutions to problems and facilitate the co-creation of social innovation.

These changes have given rise to new educational institutions such as corporate universities, consortium, and online universities, etc. The rise of new actors like corporate university and consortium provides an open platform for business and academia intending to produce new products and services or improve the existing one. In addition, businesses and corporate universities help in the integration of the practical side of learning with theoretical balance and provide more funding opportunities and responses from the market, thus improving the innovative capabilities of higher education institutions. In addition, the rise of new learning models like Massive Open Online Courses (MOOC) and learning modes such as distance learning, e-learning have come as a future model in the education system. The new digital and virtual learning methods can deliver cheap or even free education to many students at a time [97]. The digital technologies support social innovation processes that demand an open environment and decentralization, in which knowledge can be produced in the societal context with the involvement of diverse groups of actors [98].

5.2. Action-Based Research and Entrepreneurship

The action-based research is a key component through which actors can learn and foster social innovation practices. Action-based research includes four major phases: planning (problem definition), acting (implementation of the strategic plan), observing (perceiving and evaluating the action), and reflecting (critical reflection on the whole process, helps them to gain a better understanding of issues and problems. The action-based research provides more systematic and holistic ways in technology development.

HEI involvement in entrepreneurship allows them to participate in various market-oriented activities without leaving behind academic values. Their participation in businesses provides them the ability to respond with complex surroundings with greater autonomy. Entrepreneurial activities can maintain the self-sufficiency and autonomy of institutions, and generate both economic and social benefits. In addition, entrepreneurship is important for the growth and innovation that converts novel ideas and new knowledge to successful innovation (products and services), which is necessary to gain a competitive advantage and improve their connection with local community [99–101]. To respond to changing research needs and societal technology challenges, HEIs should actively participate in various research and entrepreneurial activities that facilitate technology development and commercialization by obtaining patents, then licensing them and spinning-off companies [102–107]. The rise of entrepreneurial universities will help to better serve these functions in the future.

5.3. Rise of New Concepts of Collaborative Spaces

Social innovation focuses on the active involvement of citizens in the generation of public value [108]. The engagement of HEIs in social innovation encourages academicians and students to deliver a variety of social services by participating in community-development activities or service-learning [106]. The concept of transformative learning and systemic thinking uses educational practices to bring innovative and sustainable social changes. This concept can enable HEIs and other engaged actors to work on new ideas for social change and to create social impact. The European Union's (EU's) Transformative Social Innovation Theory (TRANSIT) project from 2014–2017 was set to develop a theory that focuses on the function of co-creation in social innovation [45]. The project emphasized on requirements of physical spaces (Table 3) like "Science shop", "Living lab" or "Desis Lab", which HEIs can use to provide a collaborative platform to engage stakeholders for knowledge exploration and mutual learning and help them to perform their activities outside the academic setting in the societal context [28]. Several other educational organizations and universities provide different interactive spaces, such as Hackerspace (focus on electronic and computer programing) and Fab Lab (workshop space with set tools) that promote sharing of facilities for co-creation and co-production of knowledge [109]. The societal value generated by such facilities brings a transformation that directly or indirectly influences society. These spaces facilitate co-operation between HEIs and society, and translate the university knowledge in response to community knowledge needs. They then use this knowledge to improve research and education, thereby empowering both of the actors.

Table 3. New concepts of physical spaces in social innovation.

Type of Association	Supporting Activities	Examples
Community Workshop Hackerspaces and Fab Labs	- Sharing of physical spaces, tools or other items - Interactive knowledge exchange and learning - Sharing different forms of knowledge, practices, information	European Union (EU) universities, University of Sussex, United Kingdom MIT's Center for Bits and Atoms
Living Knowledge Science Shop,	- University's co-ordination with civil society - Community-based research - Knowledge exchange for co-creation	United Nation (UN) establishes 17 academic Impact Hubs for SDGs
Desis Network (Design for social innovation Network)	- Desis Lab is based on the use of design school thinking in creating value - Co-design and co-learning network for social innovation	48 Desis Lab in Europe, Asia, North and South America, Africa and Oceania France, École nationale supérieure de création industrielle (ENSCI) Paris Desis Lab Korea, Yonsei Desis Lab Korea, Seoul National University (SNU) Desis Lab India Ahmedabad, National Institute of Design (NID) Desis Lab
Living Lab	- Re-create relationship between university and civil society - Improve user/people participating in the research and innovation process - Focus on the utilization of ICT technologies for society	The European Network of Living Lab (ENoLL) Learning Lab University of Leeds University of Plymouth
Ashoka	- Collaborate with HEIs and universities - Financial and networking support for social entrepreneurship - Changemaker Campus to support culture and practices of social innovation	45 Colleges and universities (37 in US) Such as Northeastern university Arizona state university Cornell University Hanyang University Korea (First East-Asian changemaker campus)
Impact Hub	- Building social entrepreneurship community to bring impact - Support social and business innovation - Provide co-working spaces for co-creation - Knowledge Mobilization Idea cultivation	Around 95 local Impact Hubs across 5 continents and more in the process of making

6. Proposition Based on Reseach Question and Recommended Action Plans

6.1. Proposition Based on Discussing Research Questions

This paper aims to discuss the following problem statements and research questions:

Q1: How can HEIs improve their capabilities and capacity that can increase opportunities for social innovation learners to engage in different activities related to CoSoI and can enhance their participation in bringing societal change?

HEIs adopt different learning models and a systemic thinking approach that provides stages for the development of social innovation and manages the action towards successful innovation. For example, project-based and collective experimental learning includes more place-based learning methods that offer an opportunity to learners to upgrade their individual and social skills towards innovation. The key elements of all the learning models are based on critical reflection and rational thinking that encourages moderation in previous assumtions and mind frame. HEIs also critically analyzes and evaluates these learning models and provides feedback which is important to improve the effectiveness of the strategy and is helpful in redesigning the process based on reflection and outcome.

Q2: In a multi-actor innovation ecosystem, how can the learning activities and systemic thinking approach support HEIs to participate in the co-creation of social innovation? What are the roles played by HEIs in facilitating multi-actors for the CoSoI process?

In innovation ecosystem, HEIs play a pivotal role as a network facilitator and mediator that improve the connectivity between the actors to stimulate innovation. Learning processes in HEIs such as social learning focuses on mutual respect and valuing relations that are the core element of networking and collaboration. The learning processes provide necessary skills that allow HEIs to participate in critical functions of maintaining the relationship and collaboration between stakeholders, and in the formation of interfaces among education, research, and society to transfer the benefits of innovation to the larger community. In addition to learning processes, systemic thinking is also important for HEIs to expand their capabilities and to develop multiple competencies useful for CoSoI.

Social innovation learning stresses the need for an open engagement platform that enables the integration of resources to facilitate co-creation. This platform helps to integrate resources and capabilities and to manage collaboration by orchestrating actors to promote successful innovation. HEIs proactive engagement in open networks and collective innovation improves knowledge mobility and disseminates knowledge to businesses and society. Furthermore, HEIs can provide mutual ground and supportive infrastructure that enables the mobilization of funds to sustain the value generation process and consequent innovation.

Based on two major research questions, the following propositions are developed to test the hypothesis for future research:

- In the case of CoSoI practices, which requires learning for problem-solving skills based on critical reflection and evaluation to create and transform capabilities results formulation of an effective strategy for social innovation.
- Co-creation in the innovation ecosystem requires collective action and collaboration that embrace social relation, incorporating learning in social context cultivate new skills, knowledge, and capabilities and enhance knowledge sharing and network connectivity.
- The networking and collaboration through learning processes also influence power relations and leadership of dominance institutions based on trust developed during learning. This reduces the differences in attitudes, values, and perspectives.
- Learning processes along with the systemic approach is important for transforming capabilities and long-term organizational changes that are required to foster societal innovations by changing attributes and behavior as well as organizational culture.

6.2. Recommended Action Plan Based on Proposed Framework

Figure 3 suggests an action plan based on our proposed framework. Figure 3 outlines the action plan for HEIs and other actors like society and policymakers to support and encourage CoSoI. These action plans can serve as guidelines for them to improve capacity and social innovation learning. For example, HEIs need to change traditional learning methods and support an environment conducive to social innovation learning such as experimentation based learning and transformative learning that can motivate students towards social innovation initiatives. Management and entrepreneurial education provided by HEIs encourage the risk-taking abilities of students for social entrepreneurship, which requires proper platform and funding support from other partners. Similarly, citizens should be aware of the educational programs and policies to get optimum benefits. Implementation of social innovation requires a mutual process where all partners are equally involved in the co-creation of innovation.

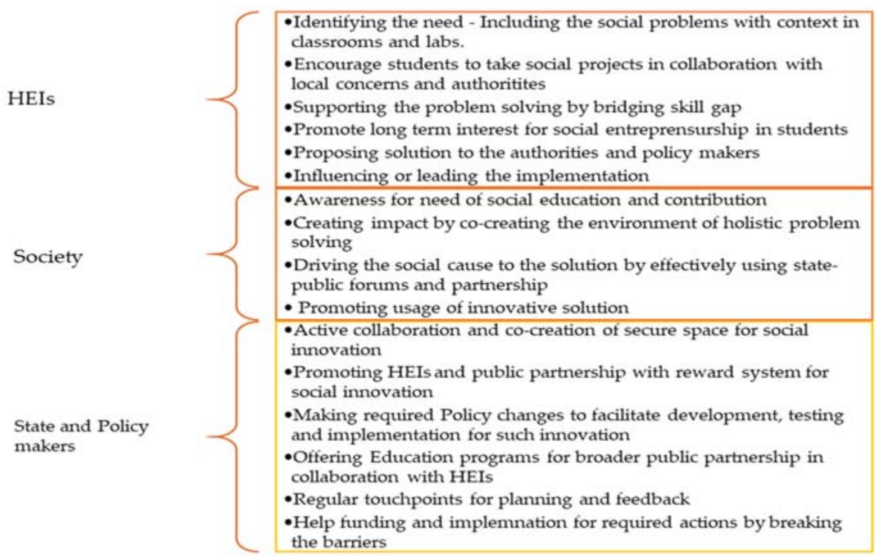

Figure 3. Recommended action plan based on framework.

7. Discussion

This study presents a conceptual framework on how HEIs can facilitate CoSoI through a learning and systemic approach and highlights the key mechanism underlying the process. An integrated table showing an overview of the process and functions of HEIs in CoSoI is tabulated in Table 4. Firstly, the paper elaborates on the different steps in the process of CoSoI which includes problem identification, engaging relevant actors for co-creation, mutual learning, and knowledge exchange among the actors which results in resource integration and change in relations, and the final step is joint exploitation of knowledge by actors for successful innovation. These steps in the CoSoI process provide an understanding of the process and evaluate the changing impact. To fulfill the goal of CoSoI, different types of learning processes and a system thinking approach are elaborated that can encourage social innovation capabilities and can empower the actors to improve their access to funds and resources, and can promote collaboration. The learning processes reviewed in the paper focuses on a set of underlying features like critical reflection, transforming capabilities, and evaluation that helps learners to transform their skills and abilities. These collective learning processes in social settings provide the necessary skills and competence to co-create and implement successful innovation.

Table 4. Overview of process and function of HEIs in Co-creation for Social Innovation.

Objective	Achieve Social Demands and Challenges through the "CoSoI" Process			
HEIs Function in the Process	**Knowledge Sharing and Collective Learning**	**Collaborative Research and Entrepreneurship**	**Network Facilitator and Proactive Collaborator**	**New Collaborative Physical Spaces**
Channel of Contribution	Education and Skill Development Mutual Learning Knowledge Diffusion Awareness for Social Problems Virtual Learning Methods ICT and Digital based Solution Transdisciplinary Education Science and Engineering Balance	Basic and Applied Research Participatory Research Action Learning Licensing and Spin-Off Technology Transfer Business Incubation Start-ups and Venture Creation Support Commercialization	Mediator in Collaboration Engagement Platform Support Research Integration Orchestration of actors	Service-learning Increase openness and Open Collaboration Living Laboratories Fab Lab
Key Resources	Professors, Students, Knowledge, Facilities from Different actors, Multidisciplinary Knowledge Science Shop	Students and Academician Technician and Researchers Joint Lab Support DesisNetwork and Fab Labs Technology Transfer office	Integrated Knowledge, Facilities and Equipment Physical Space (e.g., Hackerspaces)	Professors, Students, Researcher Civil society
Outcomes	New Solution to address Societal Needs and Challenges	Building of New Networks and Relationship	New knowledge and Value Creation	Public Value Social Change Sustainability

The learning processes used in the framework is based on knowledge sharing and a collective experimentation process which strengthen HEI capacity to serve with a broad range of responsibilities and support social innovation initiatives. Designing learning based on key components can provide direction and motivation to learners to initiate the social innovation process. In addition, it is important to combine a systemic approach with the learning processes that could be helpful to identify the organization as a system and emphasizes the interrelationship, arrangements, and response structures that come together to generate innovation and can bring value propositions to the wider society. In addition, both learning and a system change approach strengthened organizational abilities to research and entrepreneurship by supporting key mechanisms of network collaboration and resource exchange activities. Thus, HEIs are required to be innovative in educational methods and curricula redesigning which should be done at a regular interval considering the notion of social innovation.

The study is useful for several reasons and has policy implications at different levels. In general, the study provides an understanding and importance of co-creation in the social innovation process, which is useful in social innovation practices. Second, the framework outlines how HEIs can contribute to facilitating CoSoI through different learning processes and systemic change that can support the development of innovative capabilities. In addition, the paper provides a recommended set of action plans that can serve as guidelines for educational institutions, the public, and policymakers to better implement the process. Redesigning educational methods and restructuring of institutions based on systemic change can help students to improve their skills and reduce the gap between educators and learners to understand the process and action plan. Furthermore, redesigning and reevaluation of learning processes help policymakers to formulate effective policies that align with the mission and goals of social innovation education. For successful implementation of CoSoI, HEIs will require a conducive environment and regulation where they can enjoy enough autonomy, funding support, and improved transformative capabilities. This study is limited to theoretical and conceptual methods based on systemic literature review and the paper provides propositions that are developed to test the hypothesis in future empirical study to answer the research questions.

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Appendix A

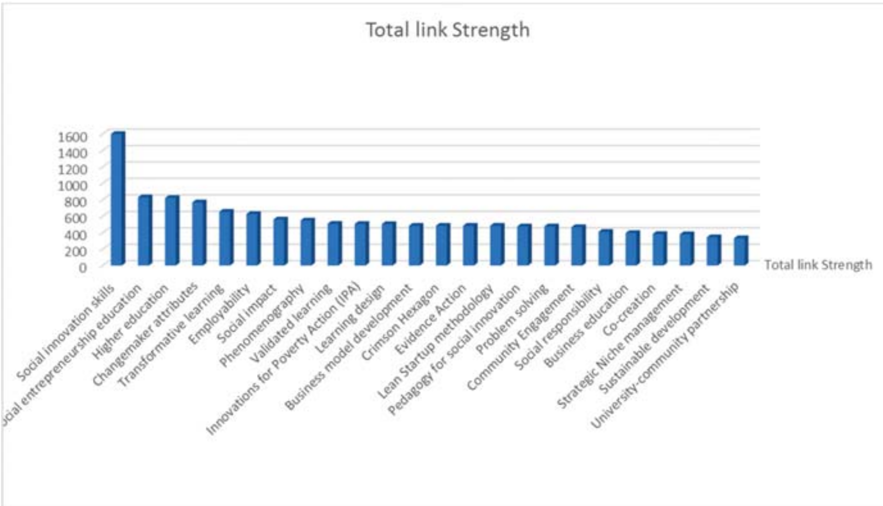

Figure A1. Keywords as per total link strength fromWoS author's keyword database.

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Developing the Entrepreneurial University: Factors of Influence

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Abstract: Universities are increasingly paying more attention to developing academic entrepreneurship. This paper analyses the existing relationships between the relevant factors that contribute to the development of the entrepreneurial university. A previously validated questionnaire was administered to a sample of 84 deans of a number of faculties in Spain. The aim was to assess the universities' development in terms of 13 influencing factors in encouraging entrepreneurship. The findings show that universities' contextual factors had only minor influence on internal factors. Internal resources were found to be moderately or highly correlated with the processes put in place by universities to promote entrepreneurship. In particular, reference to entrepreneurship in a university's mission, strategy, policies and procedures had a correlation with all the entrepreneurship factors analysed. Support from the management team and organisational design were not among the most important factors; however, they were positively associated with training and research processes, which, in turn, seemed to be strongly related to all factors in the development of the entrepreneurial university, especially with university mission and strategy. The findings show the relationships between the factors involved in the development of the entrepreneurial university. This will help universities to adopt measures that are better suited to promoting entrepreneurship.

Keywords: entrepreneurial university; entrepreneurship; triple helix; higher education; influencing factors

1. Introduction

Universities emerged from monastic (scholastic) schools in the twelfth and thirteenth centuries. Their teaching and research roles were only added much later with the creation of the University of Berlin, which has been regarded as the first modern university, and which was created in 1810 [1]. Currently, five types of universities can be identified in terms of their role [2]. First, the academic university, which is largely aimed at teaching students. Second, the classic university, where research is combined with teaching. Third, the social university, which takes an active part in the discussion and resolution of society's problems. Fourth, the business university, where teaching and Research and Development activities are carried out based on business criteria. Fifth, the entrepreneurial university, which has a strong role in the social context within which it operates. In addition to the basic teaching and research functions, a third key mission for society should be incorporated into universities: Fostering entrepreneurial projects or conducting development projects working together with other agents within the regional system [3]. Universities can be actively engaged in these projects, as they are close to the markets and have sound knowledge of the different trends as they emerge [4]. In today's knowledge society, universities are increasingly and more directly becoming promoters of economic and social development [2]. Universities have recognized the role of education in building societies based on values of equity, social justice and sustainability.

The term entrepreneurial university was coined by Etzkowitz in 1998 [5], and refers to regional economic development [6]. This concept is also known as the triple helix model, which describes the relationship between universities, industries and governmental organisations intended to stimulate innovation [7], create incubators and/or support structures for lecturers and students to start new businesses [8] and raise awareness of and promote entrepreneurship [9]. Other authors, including Subotzky (1999, quoted in 8), have defined entrepreneurial universities as those where a closer partnership exists between academia and businesses; where faculties have greater responsibility for obtaining external funding; and where there is a managerial ethos in institutional governance, leadership and planning. It should be noted that the relationship between these three actors, university, industry and government, is interdependent; in other words, these actors condition each other and constitute an organic unit [10].

While no consensus exists about a single definition of the entrepreneurial university, several authors have listed a number of features that characterise it [11]. However, there are few models that explain the entrepreneurial university's foundations and conceptual basis. There is also a paucity of empirical studies on the subject [7]. The majority of the research carried out has been based on conceptual frameworks that seek to identify the features that should characterise the entrepreneurial university. As an example, O'Shea et al. [6] proposed a number of factors that could bolster the entrepreneurial university, namely top-down leadership, policies that support and encourage the process of academic entrepreneurship, own funding, technological transfer offices and incubators, an entrepreneurial culture, entrepreneurial attitudes and aptitudes, access to venture capital, infrastructures and technology clusters. Baporikar [12] highlights the context and organizational aspects to understand the entrepreneurial university.

Only a few studies have empirically analysed the entrepreneurial university [8,13–16], most of which have relied on the different factors involved in building their conceptual frameworks. Moreover, Riviezzo, Napolitano and Fusco [17] highlight that empirical assessment of the social and cultural impacts of the university in a community has been largely overlooked.

A specific area of research interest is in analysing factors based on the creation of university spin-offs, which seeks to identify why some universities are more successful at generating them [6,18–22]. However, the literature is scarce on the factors that make up the entrepreneurial university as a whole; instead, research tends to be focused on proposing theoretical models that are yet to be empirically demonstrated [23,24].

Based on their review of 17 studies centred on identifying which factors are important in fostering the entrepreneurial university, and how the entrepreneurial university influences regional development, Guerrero-Cano et al. [25] indicated three formal factors (governance organisation and structure; support measures to start new businesses; and an entrepreneurial university) and three informal factors (attitudes of the university community; teaching methodologies aimed at entrepreneurship; and an academic reward system) that are conducive to strengthening the entrepreneurial university.

In 2013, the Organisation for Economic Co-Operation and Development (OECD, 2013) and the European Commission issued the self-evaluation tool HEInnovate (higher education institutions innovation) [26]. This tool is intended to assess the entrepreneurial and innovative potential of higher education institutions across eight key areas. The key areas directly related to the aims of this paper are those related to entrepreneurial teaching and learning, and to the support of entrepreneurs.

Since the studies published to date are not focused on models that encompass all the factors covered in the literature, there is a need to further the knowledge of the determinant factors of the entrepreneurial university, and the extent of their influence. To this end, Errasti et al. [27] devised and validated a model of maturity for the measurement of the level of academic entrepreneurship among faculties and universities. The model included thirteen factors: Legal and administrative context; business and organisational context; entrepreneurship funding; training in entrepreneurship for faculty staff; inclusion of professionals from businesses and organisations in the development and delivery of the curriculum; mission and strategy; policies and procedures; support from the management team;

organisational design; training and research in entrepreneurship; extra-curricular training; active methodologies; and internationalisation.

The study conducted by Errasti et al. [27] concluded that there was a modest degree of development in the various elements involved in the entrepreneurial university, and that there is still much room for improvement. It also showed that the most developed factors among Spanish universities were internationalisation, use of active methodologies, mission and strategy and support from the management team. In contrast, the least developed factors were found to be entrepreneurship funding; business and organisational context; training in entrepreneurship for faculty staff; and the legal and administrative context.

While some studies have focused on identifying which factors promote the entrepreneurial university, others have highlighted some potential correlations between those factors. This is the case of Fini et al. [21], who held that a close interaction between local businesses or organisations and the university help create a social environment that supports people and encourages them to share knowledge and ideas. Guerrero and Urbano [28] and Hu [29], for their part, argued that funding was essential for a university's autonomy and development. Davey et al. [30] and De Luca et al. [31] concurred that the collaboration of external business experts in advising on and developing the curriculum fosters both university-business cooperation processes and the acquisition of key skills by future entrepreneurs.

Errasti et al. [27] presented a descriptive analysis of the factors that contribute to the development of the entrepreneurial university. Following this study, the main research question of the present paper is: What are the existing relations among these factors? Therefore, the overall aim of this study is to determine whether there are associations between the levels of development of some factors involved in the entrepreneurial university that indicate significant influence relations to help further its advancement. This aim will be specifically focused on the following objectives:

1. To identify to what extent external contextual factors are related to the development of the entrepreneurial university.
2. To identify to what extent having different types of resources relates to the development of the entrepreneurial university.
3. To analyse to what extent the processes that a university puts in place in connection with its projects, structure and training are interlinked and also connected to other external and internal factors.

2. Hypotheses and Variables

As indicated, the variables under study in this work have been the characteristics of the entrepreneurial university identified by the literature and that have been previously validated as constituent factors of it. More specifically, in order to respond to the objectives set out, the relationship between these variables has been analysed. To this end, the hypotheses expressing the expected relationships between these factors have been formulated, based on the literature and previous research. Below, we detail how the conceptual definition of these variables has been made, as well as the operational definition through the elements of each one of them that are evaluated with the instrument developed for their measurement.

The hypothesis that guide the study have been organised according to the CIPP model [32], a model for institutional evaluation that uses contextual, input, process and product factors. The hypothesis of the study can be stated as follows.

In the first place, the models for institutional evaluation that use contextual, process and product factors have traditionally advocated that contextual factors help to explain other internal (process and product) factors and variables, since they have an impact on them to a greater or lesser extent. This impact has been attributed to the fact that they outline the conditions for intervention, as they consider explanatory and control variables related to political, legal, administrative, demographic, socio-economic and cultural conditions.

Hypothesis 1 (H1). *External contextual factors (Legal and Administrative Context, Business and Organizational Context) are positively related to the development of internal factors. This hypothesis has been supported by previous literature on the development of the entrepreneurial university* [33–35]. See Table 1.

Table 1. Hypotheses and variables (conceptual and operational definition) related to the context of the entrepreneurial university.

Hypotheses	Variables—Conceptual Definition of Factors	Elements for Its Operational Definition	Alpha
Hypothesis 1 (H1)	**1.** Legal and administrative context: Government and public administrations become involved in and facilitate entrepreneurship.	1.1. Legislation 1.2. Financing 1.3. Public infrastructures	0.896
	2. Business and organisational context: Nearby organisations and companies that operate in the same or a similar business sector, and interact with the university by sharing the same field of research, knowledge and ideas through formal and informal networks.	2.1. Financing 2.2. Technological level 2.3. Innovation level 2.4. Technological maturity 2.5. R & D budget	0.893

Secondly, resource factors are intended to account for the inflows into the system, both in the form of material (economic, infrastructure) resources and human resources (staff) available for an organisation to operate. See Table 2.

Hypothesis 2 (H2). *Resource factors (Entrepreneurship funding, Training in Entrepreneurship for Faculty Staff, Inclusion of professionals) are related to the development of institutional statements linked to entrepreneurship (Mission and Strategy, Policies and Procedures).*

Hypothesis 3 (H3). *Resource factors (Entrepreneurship funding, Training in Entrepreneurship for Faculty Staff, Inclusion of professionals) are associated with the development of structures that support entrepreneurship (Support from the management team, Organisational Design).*

Hypothesis 4 (H4). *Resource factors (Entrepreneurship funding, Training in Entrepreneurship for Faculty Staff, Inclusion of professionals) are related to the development of processes for entrepreneurship (Training and Research in entrepreneurship, Extra-curricular entrepreneurship training, Active methodologies, Internationalisation).*

Table 2. Hypotheses and variables (conceptual and operational definition) related to the resources of the entrepreneurial university.

Hypotheses	Variables—Conceptual Definition of Factors	Elements for Its Operational Definition	Alpha
Hypothesis 2 (H2) Hypothesis 3 (H3) Hypothesis 4 (H4)	**3.** Entrepreneurship funding: This factor demonstrates the autonomy of the university, shows the funds for research and teaching in entrepreneurship, and for creating entrepreneurship projects and setting up companies and organisations.	3.1. Funding for entrepreneurship teaching 3.2. Funding for research into entrepreneurship 3.3. Seed Capital	0.880
	4. Training in entrepreneurship for faculty staff: Extent to which the university provides training in entrepreneurship to its staff, in terms of transfer of knowledge and in the creation of spin-offs so that they can promote entrepreneurship among their students.	4.1. Training in entrepreneurship 4.2. Transfer of knowledge 4.3. Creation of spin-offs	0.878
	5. Inclusion of professionals from businesses and organisations in the development and delivery of the curriculum: Examines the presence of experts from the business world and/or practising professionals or agents from nearby organisations and/or from the same business sector in the design, development and delivery of the curriculum. Includes university-company collaboration in the development of course programmes, modules, experiences, etc., as well as the inclusion of guest lecturers.	5.1. Participation in the main governing body of the faculty 5.2. Participation in development and delivery 5.3. Lecturers and guest professionals	0.889

In the third place, process-related factors account for the processes that an organisation puts in place to operate and provide its services. They may be related to the projects it carries out, which guide its actions; to the structures organised to implement them; or to the training processes whereby it operates (by means of the key training process). See Table 3.

Table 3. Hypotheses and variables (conceptual and operational definition) related to the processes—projects, structures, training and research—developed by the entrepreneurial university.

Hypotheses	Variables—Conceptual Definition of Factors	Elements for Its Operational Definition	Alpha
Hypothesis 5 (H5) Hypothesis 6 (H6) Hypothesis 7 (H7)	**6.** Mission and strategy: Analyses whether the mission statement and strategies of the university include the word 'Company/Organisation' or 'Entrepreneurship' in any of its documents (mission, vision values, strategic plan).	6.1. Presence in the mission 6.2. Objectives 6.3. Strategy on knowledge transfer 6.4. Strategy for university-business/organisation partnership 6.5. Strategy for entrepreneurship 6.6. Strategies related to social responsibility 6.7. Monitoring and evaluation of results	0.876
	7. Policies and procedures: Evaluates the existence and possible influence of university policies, procedures and practices on Academic Entrepreneurship Activities, such as university policies on intellectual property and networking activities for university-business collaboration, and university spin-offs.	7.1 Policies and procedures on knowledge transfer 7.2. Policies and procedures for university-business/organisation partnership 7.3. Policies and procedures for the creation of spin-offs	0.879
	8. Support from the management team: Analyses the leadership, understanding and support of the management team regarding the entrepreneurial culture in the university, as shown in decision making, behaviours and actions that influence the university's strategy	8.1 Support for entrepreneurship 8.2. Revenue for entrepreneurship 8.3. Presence on the agenda	0.887

Table 3. *Cont.*

Hypotheses	Variables—Conceptual Definition of Factors	Elements for Its Operational Definition	Alpha
	9. Organisational design: Analyses the extent to which a university facilitates entrepreneurial behaviour within it through its own organisational design mechanisms, such as the decentralisation of decision making, flexibility in the integration of strategies, financial autonomy, the relationship between teaching and research and the degree to which individuals have the power to innovate.	9.1 Connection between teaching and research 9.2. Decentralised decision- making 9.3. Bottom-up structure 9.4. Financial autonomy	0.890
	10. Training and research in entrepreneurship: Formal education in entrepreneurship can be defined as the development of competences (behaviours, knowledge, skills and attitudes) specific to the person within academic curricula and in research.	10.1. Entrepreneurial skills in the curriculum 10.2. Specific programmes on entrepreneurship 10.3. Research	0.876
	11. Extra-curricular training: The extra-curricular training process for academic entrepreneurship refers to the training activities carried out outside the curriculum, such as awareness-raising, workshops for the identification of opportunities and courses for the implementation of innovative projects, the development of business plans and the launch of spin-offs.	11.1. Raising awareness about entrepreneurship 11.2. Identification of opportunities 11.3. Business plan development 11.4. Launch of spin-offs	0.878

Table 3. *Cont.*

Hypotheses	Variables—Conceptual Definition of Factors	Elements for Its Operational Definition	Alpha
	12. Active methodologies: Entrepreneurship education professionals should be able to create an open environment in which students develop the confidence to take risks and learn from their successes and failures, participation in real projects and works, are all active methodologies that can foster the development of entrepreneurship.	12.1. Use of active methodologies 12.2. Placements with entrepreneurs 12.3. Design and development of innovative educational resources	0.885
	13. Internationalisation: Development of joint degrees with universities abroad, the carrying out of international research projects and the mobility activities of students, academics and/or partners are key elements of the entrepreneurial university	13.1 Joint degrees 13.2. Research 13.3. Revenues 13.4. Mobility	0.892

Hypothesis 5 (H5). *The existence of entrepreneurship Projects (Mission and Strategy, Policies and Procedures) would be related to Structures that support entrepreneurship (Support from the management team, Organisational design).*

Hypothesis 6 (H6). *The existence of entrepreneurship Projects (Mission and Strategy, Policies and Procedures) would be associated with entrepreneurship Training Processes (Formal entrepreneurship training, Extra-curricular entrepreneurship training, Active methodologies, Internationalisation).*

Hypothesis 7 (H7). *The existence of Structures that support entrepreneurship (Support from the management team, Organisational design) could be expected to be related to the development of entrepreneurship Training Processes (Formal entrepreneurship training, Extra-curricular entrepreneurship training, Active methodologies, Internationalisation).*

3. Materials and Methods

The sample invited to participate in this study was made up of 567 faculties, schools and affiliated centres belonging to 44 universities (public and private) from six autonomous regions, those identified in the literature as being benchmarks in academic entrepreneurship in Spain [36,37]. Participation was voluntary, and confidentiality was guaranteed through a letter requesting their cooperation and informed consent.

A total of 98 subjects from the invited sample responded to the request for participation. After a preliminary analysis, 14 were eliminated because of their atypical responses (extreme and outstanding cases in the box diagram). This led to the final sample consisting of 84 cases, 14.81% of the invited sample.

The percentage of participation of public institutions was greater than that from private ones (76% and 24%, respectively). Five different areas were taken into account for the study. While the subject areas were not homogeneously represented, the participating autonomous regions were.

In order to meet the research objectives, a questionnaire was used that had been previously designed and validated by Errasti et al. [27] to measure the maturity of academic entrepreneurship among different faculties. This questionnaire, based on the original instrument by Markuerkiaga et al. [38], consisted of 14 blocks of mostly closed questions, with the inclusion of a smaller number of open questions to allow participants to provide evidence and/or add comments and clarifications. The first 13 blocks were required to be answered, while block 14 was optional. The questionnaire was preceded by a section where each faculty's general and descriptive data were recorded.

The questionnaire included a total of 13 blocks and 48 elements, with mandatory matrix questions rated on a 10-point Likert-type scale, and were grouped into three levels (low, medium and high). A rubric with descriptors and mutually exclusive response options were employed. The blocks and elements included have already been stated in the previous section. This dimension also contained an optional open-ended question aimed at obtaining comments, clarifications and evidence that the subjects may wish to provide.

Following the design of the contacts database, the questionnaire was sent from the internal messaging system of the Qualtrics programme (tool used for creating, collecting and consolidating surveys). A reminder was sent two weeks later and another one within a month after the questionnaire had been distributed. All data collection was conducted online.

It is important to emphasise that, during the data collection process, all necessary steps were taken to ensure the confidentiality of the participants. Time and resources were devoted to explaining the purpose and nature of the research. The individual freedom to participate in the research was respected at all times, and participants were informed about how the results would be used [39].

4. Results

As the variables used were quantitative, the correlation index that expressed 'an estimation of the degree to which two variables vary together' was analysed, in order to study the relationship between the thirteen factors assessed by the questionnaire [40]. Pearson's correlation coefficient was employed in order to analyse the relations between variables, considering those associations that were significant at a confidence level of 0.99 and 0.95. Moreover, the size of the correlation was valued as low, moderate or high, in accordance with the recommendations made by Bisquerra [39] in the field of educational sciences. In light of the wide range of the variables, the most important findings will be discussed in connection to the different types of factors. Table 4 shows the factors correlation matrix.

4.1. Contextual Factors

Table 4 shows the correlations between Factor 1, legal and administrative context, and Factor 2, business and organizational context, with the rest of the factors. These conclusions can be drawn from the data analysis:

- Factor 1, legal and administrative context, showed a significant but low correlation with the following factors:
  - Resource factors: Funding for entrepreneurship (0.21, significant at the 0.05 level) and Training in entrepreneurship for faculty staff (0.29, significant at the 0.01 level).
  - Project-related factors: Mission and strategy (0.24, significant at the 0.05 level) and policies and procedures (0.32, significant at the 0.05 level).
  - Structural factors: Organisational design (0.22, significant at the 0.05 level).
  - Training process factors: Training and research in entrepreneurship (0.25, significant at the 0.05 level) and extra-curricular training (0.27, significant at the 0.05 level).
- Factor 2, business and organizational context, showed a low significant correlation with the following factors:
  - Resource factors, funding for entrepreneurship (0.24, significant at the 0.05 level) and training in entrepreneurship for faculty staff (0.29, significant at the 0.01 level).
  - Project-related factors: Mission and strategy (0.24, significant at the 0.05 level) and policies and procedures (0.27, significant at the 0.05 level).
  - Structural factors: Organisational design (0.22, significant at the 0.05 level).
  - Training process factors: Training and research in entrepreneurship (0.23, significant at the 0.05 level), extra-curricular training (0.30, significant at the 0.05 level) and internationalisation (0.26, significant at the 0.05 level).

To further the analysis. Student's t-test was used to compare those faculties that were above and below the mean score of these two factors. No significant difference was found between them in terms of their level of development of the remaining factors.

Table 4. Factors correlation matrix.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13
F1.Legal and administrative context	1	0.627 **	0.218 *	0.293 **	0.156	0.244 *	0.325 **	−0.003	0.223 *	0.256 *	0.276 *	0.154	0.205
F2.Business and organisational context	0.627 **	1	0.247 *	0.290 **	0.214	0.240 *	0.274 *	0.139	0.220 *	0.237 *	0.301 **	0.013	0.267 *
F3.Entrepreneurship funding	0.218 *	0.247 *	1	0.605 **	0.453 **	0.548 **	0.423 **	0.503 **	0.322 **	0.596 **	0.571 **	0.555 **	0.275 *
F4.Training in entrepreneurship for faculty staff	0.293 * *	0.290 **	0.605 **	1	0.356 **	0.595 **	0.640 **	0.362 **	0.294 **	0.599 **	0.670 **	0.440 **	0.424 **
F5.Inclusion of professionals	0.156	0.214	0.453 **	0.356 **	1	0.457 **	0.407 **	0.384 **	0.276 *	0.407 **	0.358 **	0.471 **	0.124
F6.Mission and strategy	0.244 *	0.240 *	0.548 **	0.595 **	0.457 **	1	0.695 **	0.508 **	0.448 **	0.775 **	0.611 **	0.549 **	0.448 **
F7.Policies and procedures	0.325 **	0.274 *	0.423 **	0.640 **	0.407 **	0.695 **	1	0.391 **	0.465 **	0.521 **	0.529 **	0.393 **	0.421 **
F8.Support from the management team	−0.003	0.139	0.503 **	0.362 **	0.384 **	0.508 **	0.391 **	1	0.314 **	0.510 **	0.475 **	0.369 **	0.306 **
F9.Organisational design	0.223 *	0.220 *	0.322 **	0.294 **	0.276 *	0.448 **	0.465 **	0.314 **	1	0.348 **	0.196	0.317 **	0.349 **
F10.Training and research in entrepreneurship	0.256 *	0.237 *	0.596 **	0.599 **	0.407 **	0.775 **	0.521 **	0.510 **	0.348 **	1	0.694 **	0.533 **	0.411 **
F11.Extra-curricular training	0.276 *	0.301 **	0.571 **	0.670 **	0.358 **	0.611 **	0.529 **	0.475 **	0.196	0.694 **	1	0.580 **	0.351 **
F12.Active methodologies	0.154	0.013	0.555 **	0.440 **	0.471 **	0.549 **	0.393 **	0.369 **	0.317 **	0.533 **	0.580 **	1	0.214
F13.Internationalisation	0.205	0.267 *	0.275 *	0.424 **	0.124	0.448 **	0.421 **	0.306 **	0.349 **	0.411 **	0.351 **	0.214	1

** Correlation is significant at level 0.01 (bilateral). * Correlation is significant at level 0.01 (bilateral).

Based on these data, it can be concluded that the hypothesis H1 that external factors would be associated with and influence the development of internal factors has not been validated, except for the training in entrepreneurship for staff. At first sight, this seems to contradict the hypothesis that was proven in previous studies. However, taking into account the low scores obtained for all factors and variables in the context of this study, it may indicate that it does not have a significant influence on the sample of Spanish universities analysed due to the low degree of support given by them to entrepreneurship. As Spanish universities organise their entrepreneurship activities by relying on their own resources, their entrepreneurial development might be greater if the context were more favourable and supportive, as has been the case in other countries. Only if contextual factors obtained a high score and if this score were not correlated with the development of internal factors could it be stated that such influence between factors does not exist.

4.2. Resource Factors

Table 4 shows the correlations of these resource factors with each of the process-related factors. The findings were as follows:

- Factor 3 (entrepreneurship funding) was found to have a significant but moderate correlation with the majority of the process-related factors; specifically:
    - A moderate correlation with the two project-related factors: Mission and strategy (0.54, significant at the 0.01 level) and policies and procedures (0.42, significant at the 0.01 level);
    - A moderate and low correlation, respectively, with the two structural factors: Support from the management team (moderate, with 0.50, significant at the 0.01 level) and organisational design (low, with 0.32, significant at the 0.01 level); and
    - A moderate correlation with three of the training process factors: Training and research in entrepreneurship (0.59, significant at the 0.01 level); extra-curricular training (0.57, significant at the 0.01 level); and active methodologies (0.55, significant at the 0.01 level); and a low correlation with the other training process factor, internationalisation (0.27, significant at the 0.05 level).
- Factor 4, training in entrepreneurship for faculty staff, was found to have a significant (high or moderate) correlation with the majority of the process-related factors:
    - A moderate and high correlation with the two project-related factors: Moderate with mission and Strategy (0.59, significant at the 0.01 level) and high with policies and procedures (0.64, significant at the 0.01 level);
    - A low correlation with the two structural factors: Support from the management team (0.36, significant at the 0.01 level) and organisational design (0.29, significant at the 0.01 level); and
    - A moderate correlation with three training process factors and high with one: High with extra-curricular training (0.67, significant at the 0.01 level); and moderate with training and research in entrepreneurship (0.59, significant at the 0.01 level); active methodologies (0.44, significant at the 0.01 level); and internationalisation (0.42, significant at the 0.01 level).
- Factor 5, inclusion of professionals into the curriculum, had a lower correlation with process, as it was found to be either moderate or low:
    - A moderate correlation was seen with the two project-related factors: Mission and strategy (0.45, significant at the 0.01 level) and policies and procedures (0.40, significant at the 0.01 level).
    - A low correlation was seen with the two structural factors: Support from the management team (0.38, significant at the 0.01 level) and organisational design (0.27, significant at the 0.05 level).

- Correlation was moderate with two training process factors, and low with one of them, whereas there was no correlation with the other: A moderate correlation was found with training and research in entrepreneurship (0.40, significant at the 0.01 level) and active methodologies (0.47, significant at the 0.01 level); a low correlation was found with extra-curricular training (0.67, significant at the 0.01 level); and no correlation was seen for internationalisation.

To sum up, internal resource factors seemed to have a weak association with external contextual factors (against what might have been expected in H1); however, they were found to be moderately significantly associated with the development of internal processes for entrepreneurship. The strongest relationship and possible influence was found to be with training in entrepreneurship for faculty staff, and the strongest association was seen with the development of projects and with some training processes, confirming H3. Association seemed moderate (confirming partially H2) with funding for entrepreneurship. Inclusion of professionals seemed to have less association (no confirming H4); and the weakest association and possible effect was seen for the development of structures and the internationalisation process.

4.3. Process-Related Factors

4.3.1. Project-Related Factors

Table 4 shows the correlations between project-related factors and the other factors.

- Let us remember correlations found between these two project-related factors and the previous factors: Low but significant correlation with the two contextual factors, and a moderate correlation with the three resource factors, which was high between training in entrepreneurship for faculty staff and politics and procedures.
- Factor 6, mission and strategy, was found to have a significant, moderate-to-high relationship with other process-related factors:
    - Moderate with structural factors: Support from the management team (0.50, significant at the 0.01 level) and organisational design (0.44, significant at the 0.01 level).
    - Correlation tended to be high with training process factors: Training and research in entrepreneurship (high, 0.77, significant at the 0.01 level); extra-curricular training (high, 0.61, significant at the 0.01 level); active methodologies (moderate, 0.54, significant at the 0.01 level); and Internationalisation (moderate, 0.44, significant at the 0.01 level).
- Factor 7 Policies and procedures tended to be less assocaited, with a significant but moderate relationship:
    - A low correlation was observed between structures and support from the management team (0.39, significant at the 0.01 level) while a moderate correlation was found with organisational design (0.46, significant at the 0.01 level).
    - Correlation was seen to be moderate with training process factors: Training and research in entrepreneurship (moderate, 0.52, significant at the 0.01 level); extra-curricular training (moderate, 0.52, significant at the 0.01 level); active methodologies (low, 0.39, significant at the 0.01 level); and internationalisation (moderate, 0.42, significant at the 0.01 level).

In summary, all project-related factors proved to be significantly associated with all the factors studied here, albeit to varying degrees. Project-related factors seemed to be minimally influenced by internal resources. However, they were found to be strongly associated with the development of the remaining internal processes for entrepreneurship, particularly with mission and strategy, which showed a high correlation with training processes (confirming H6). The two project-related factors were also seen to be associated with the development of structures that support entrepreneurship (confirming H5), although moderately and to a lesser extent. These findings supported and validated the hypothesis that had been proved by previous studies [41] as to the importance that mission and strategy have in developing entrepreneurship at university.

4.3.2. Structure-Related Factors

Table 4 shows the correlations that structural factors had with other factors. Recalling briefly the relationships found with the factors previously analysed:

- A low correlation or no correlation with the external contextual factors.
- A low correlation with the three resource factors, which was only moderate between entrepreneurship funding and support from the management team.
- A tendency towards a moderate correlation with the two project-related factors, especially with mission and strategy.

- Factor 8, support from the management team, showed a moderate or low relationship with training processes:
    - A moderate correlation with training and research in entrepreneurship (0.51, significant at the 0.01 level) and with extra-curricular training (0.47, significant at the 0.01 level).
    - A low correlation with active methodologies (0.36, significant at the 0.01 level) and with internationalisation (0.30, significant at the 0.01 level).
- Factor 9, organisational design, had a significant relationship with training processes, although it tended to be low:
    - A low correlation with training and research in entrepreneurship (0.34, significant at the 0.01 level), active methodologies (0.31, significant at the 0.01 level) and internationalisation (0.34, significant at the 0.01 level).
    - No correlation was found with extra-curricular training.

These data seemed to reveal that Structural factors were not the most important in promoting the development of the entrepreneurial university (no confirming H7). They appeared to be minimally influenced by factors related to context and internal resources, except for the funding available. The most significant relationship was found between the Support from the management team and the training processes for entrepreneurship (curricular, extra-curricular and research processes).

4.3.3. Training-Related Factors

Table 4 shows the correlations between training-related factors and the other factors. Let us first recall the relationships identified with the factors analysed previously:

- They showed a low correlation or no correlation with external contextual factors.
- These factors had a tendency to be moderately correlated with resource factors. Correlation was only high between training for faculty staff and extra-curricular training.
- A significant correlation was identified with the two project-related factors, particularly with mission and strategy (with a tendency to have a high correlation). It was more moderate with policies and procedures.
- A moderate-to-low correlation was found with the structural factors. It was higher with support from the management team and curricular and extra-curricular training.

- In addition, a significant correlation was observed between the four factors included in the Training-related processes:

- A high correlation was identified for F10, training and research in entrepreneurship and F11, extra-curricular training for entrepreneurship (0.69, significant at 0.01), and a moderate correlation was found between F10 and the other factors F12, active methodologies (0.53, significant at the 0.01 level) and F13, internationalisation (0.41, significant at the 0.01 level).
- A moderate correlation was seen between F11, extra-curricular training for entrepreneurship and F12, active methodologies (0.58, significant at the 0.01 level).
- A low correlation was found between F11, extra-curricular training and F13 internationalisation (0.35, significant at the 0.01 level).
- No correlation was found between F12, active methodologies and F13 Internationalisation.

In short, Training-related factors showed the highest and most numerous correlations among all the factors. Despite this, they revealed low or no correlations with external contextual factors. In contrast, these factors were found to have the highest correlations with resource-related factors, which were lower and less frequent for other factors; and with structural factors, the most significant being the relationships between training for faculty staff and support from the management team with both curricular and extra-curricular training. Both of these tended to have the highest correlation with the other factors and therefore were the most sensitive to the influence of the remaining factors.

5. Discussion and Conclusions

As a conclusion, in the following figure, Figure 1, the main relations between factors found in the research can be seen. Factors have been grouped in external/contextual factors, resources and process factors, this last one including projects, structures and training processes. Factors in bold have been found as most associated to other factors of the model. These are: Entrepreneurship funding, training in entreprenerusship for faculty staff, mission and strategy, support from the management team, training and research in entrepreneurship and extra-curricular training. Arrows in bold indicate the most relevant relationships.

As it can be observed in Figure 1, external/context factors are mainly associated with training in entrepreneurship for faculty staff. Resources factors are mainly associated bilaterally to projects and training processes. Projects are associated bilaterally to structures and also training processes. It could be highlighted that training processes factors show the highest and most numerous correlations among all the factors, except with external/context factors. Those factors were found to have the highest correlations with resources factors and with projects factors.

The findings of the study showed a weak relationship between context and the development of the entrepreneurial university. The minimal influence of context was an unexpected result, since numerous studies had found precisely the opposite, namely that there was a strong relationship between the legal, administrative and economic context within which a university was placed and its entrepreneurial development [33–35]. This finding may be explained by the low scores obtained by the contextual variables in this study, or by universities relying on their own resources for entrepreneurial endeavours, thus demonstrating their autonomy. The legal and business context has traditionally had a very low level of development in Spain, and the tendency to greater awareness and support of entrepreneurship is only recent. This has been reflected in Spanish Law 14/2013, on support for entrepreneurs and their internationalisation [42], and others passed at a regional level, including Law 3/2018, on the promotion of Entrepreneurship in Andalusia and Law 16/2012, on support for entrepreneurs and small-sized enterprises in the Basque Country. It seems necessary to explore this aspect further; particularly, it would be interesting to assess the impact of this new framework in the medium- and long-term.

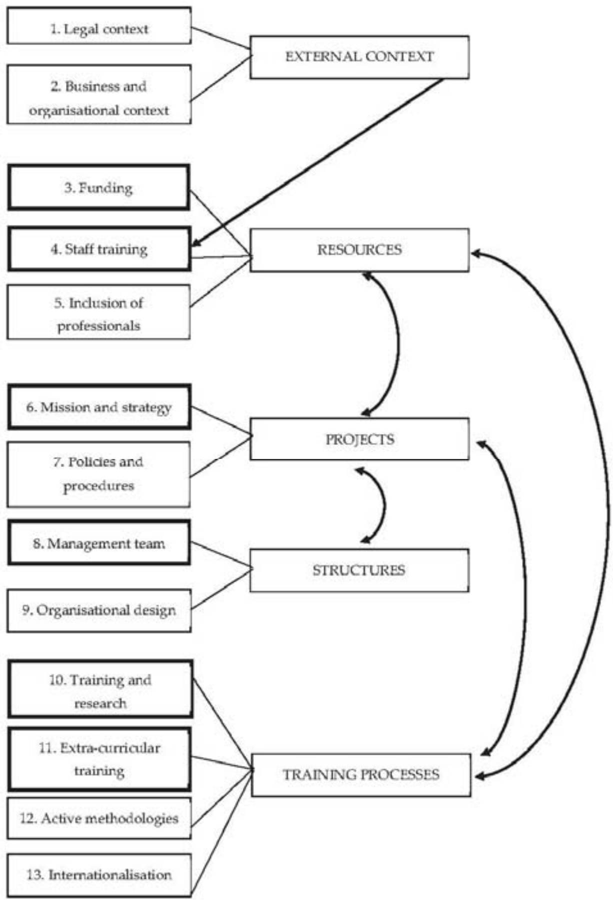

Figure 1. Factors of influence of the entrepreneurial university.

Contrary to what could be expected, the factors related to universities' resources seemed to be minimally related to external context factors, although they were found to be related to the entrepreneurship processes engaged in by universities. According to Hu [29], public and private funding is important for developing the entrepreneurial university, although this study did not identify a significant relationship between these two aspects. However, it was observed that resources were highly necessary for developing entrepreneurship; resources are to be understood not only in terms of financial provision, but also as human resources, including the involvement of professionals from the world of business and organisations in the design and delivery of the curriculum, and the increase in the numbers of faculty members with entrepreneurship training. It would appear that Spanish universities have compensated for the lack of external funding for entrepreneurship by utilising internal resources.

The projects related to entrepreneurship, which are crystallised into the mission, strategy, policies and procedures of universities, were found to be significantly associated with all of the entrepreneurship factors analysed. This was interesting, as it placed the documents that articulated the mission and strategy of universities in a very important position for developing entrepreneurship. Some studies have highlighted the importance of decision making in terms of entrepreneurship at strategic and organisational levels in the development of the entrepreneurial university [41]. Others have also stressed the influence of university policies, procedures and practices on academic entrepreneurial tasks [6].

Structures, conceived as the support from the management team and the organisational design of a university, were not among the most decisive factors for developing the entrepreneurial university as a whole. This is contrary to what could have been expected, since other studies have indicated that management teams play an essential role in promoting an entrepreneurial culture [11,43]. Nevertheless, these structures were positively associated with training and research processes, which in fact seemed to be strongly related to other factors for the development of the entrepreneurial university. Consequently, universities should consider them important and pay special attention to them. This is a highly significant finding, since training and research are core objectives of Spanish universities; and according to this study these processes are strongly related to, and have a great impact on, other factors in the development of the entrepreneurial university. As these training process factors have also been proven to be the most sensitive to the influence of the other factors characterising the entrepreneurial university, acting on any of them would have an effect on the development and improvement of entrepreneurship in education. The results of this study can be a good contribution for improvement of the Spanish entrepreneurial university and its impact on the sustainable economical and social development of the region.

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Higher Education Institutions as Knowledge Brokers in Smart Specialisation

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Abstract: The effectiveness of societal interaction has become a key aspect in evaluating the success of higher education institutions (HEIs) in performing their duties. These factors have been built into institutional funding models, and the funding of research follows a similar approach. External stakeholders are now having to share in undertaking some of the functions that will define higher education institutions' external activities, societal interaction and impact on society. The European Union's smart specialisation strategy is such a factor. This initiative allows higher education institutions to implement policies by building regional clusters. The counterparts of higher education institutions in these clusters of smart specialisation are knowledge-intensive enterprises, high-tech service providers, educational institutions, the Arctic Smartness Specialisation Platform and other centers of expertise for smart specialisation. In this paper, we have analysed the role of higher education institutions as knowledge brokers in smart specialisation though a qualitative analysis of 20 interviews conducted during the implementation of the smart specialisation project. Our findings show that the knowledge broker role can be promoted from four perspectives: the social dimension of networks; decision-making and control; cluster building; and exchange elements. The clarification and legitimation of the role of higher education institutions as knowledge brokers in these areas would give smart specialisation more impetus to reach its goals.

Keywords: higher education; knowledge brokers; knowledge intensive policies; smart specialisation; innovation ecosystems

1. Introduction

The European Commission is aiming to boost economic growth and jobs with the European Cohesion Policy and the Strategies for Smart Specialisation (S3) initiative, as a part of the Europe 2020 Strategy for smart, sustainable and inclusive growth. A total of €330 billion has been applied to the task of increasing European economic competitiveness and social welfare through research and innovation during the 2014–2020 funding period. All member states have research and innovation strategies for smart specialisation, and the regions are integrating development efforts and seeking financial support from the European Regional Development Fund (ERDF).

The objective of S3 is economic development through regionally driven priorities that correspond to the efficiency, research and innovation-related demands of the knowledge economy and knowledge society. It is about allocating the resources of research and innovation to enhance priority areas of regional funding, governance and regulation, forming a regional policy mix. It emphasises the importance of relationships between various institutions and stakeholders and encourages institutions to change by diversifying their position and goals in a global context [1,2]. A notable aspect of smart specialisation is whether or not it is the most ambiguous regional innovation policy in the world: there have been no pilot projects, nor was empirical evidence produced before it was launched.

Implementation occurred without any direct rules or guidelines for the actors or institutions to find their position in the changing environment [3,4].

Smart specialisation emphasises a place-based approach and the central role of the relational infrastructure of public institutions, as well as public and private sector cooperation, as a source of promoting regional growth [4]. However, even if public institutions including HEIs are embedded into the regional innovation system, there might also be also a gap in understanding among university management personnel about what the regional challenges are [5]. In this regard, public investment is the main source of the production of regional innovation systems, and transparent higher education institutions (HEIs) and other public institutions directly complement the support of innovation measures [1,6].

Actions to support the regional innovation system are developed through two main functions. First, the public HEIs and other research organisations have a role as a generator of new knowledge sub-systems. Second, companies and industries have a role as exploiters of knowledge sub-systems [7,8]. Earlier studies of the role of universities in smart specialisation redefined the classification of the two sub-systems mentioned above. The direction of research findings shows that, not only there are two separate roles for public and private institutions and organisations, but these roles are more diversified in the regions. Especially in small and less-developed regions, the role of public research organisations, like universities, is to have a more central role in generating and exploiting knowledge for firms and industries [4,8,9]. Previous studies have also shown that public institutions and other public resources have a significant role in regional development as institutions that connect and produce organisations and competence [1].

The roles of HEIs in processes based on smart specialisation implementation are diverse. There have been few case examples about HEIs' participation in S3 processes in regional areas, but it has been recognised that, especially in sparsely populated areas and less developed regions, HEIs tend to have had a minor role in knowledge production [10,11]. Changing practices guide the regions in coping with a changing operating environment [12]. HEIs can increase building infrastructure and administrative mechanisms to deal with knowledge absorption and new connections via institutional management [5,10]. The core missions of smart specialisation is to increase the competitiveness and sustainability of regions through specialisation activities. Internationalisation and linkages outside regional borders are significant when discussing sustainability and innovation potential. With the knowledge broker activities of HEIs, it is possible to improve at least the capacity of regional information management, exchange and linkage of knowledge, as well as the capacity building of actors in innovation systems [13].

Our aim with this paper is to analyse the role of higher education institutions as knowledge brokers in the European Union's smart specialisation program. How do knowledge brokers increase the competitiveness and internationalisation of regions? In this regard, HEIs can take a role that influences the effectiveness, interaction or renewal of the actors' work.

2. Increasing the Competitiveness of the Regions with Knowledge

HEIs as knowledge brokers in smart specialisation refers to their ability to achieve political goals, but also to the task of HEIs to increase the effective use of knowledge in regional and international networks and develop the knowledge society. Competitiveness and sustainability through responsible actions in the regions are leading goals to pursue, especially in sparsely populated areas. Responsibility that leads to sustainability forces research to be conducted about the changing role of universities in society. Understanding the development of society provides a basis for the changes needed.

2.1. Knowledge Brokers in Smart Specialisation

In regional development and innovation networks, the knowledge broker's role is to act as a gatekeeper, and to provide multiple overlapping groups with similar explanations as gatekeepers to multiple overlapping groups when knowledge brokering makes knowledge sharing possible for other actors in the innovation system. In the literature, few academics seem to have a direct impact on companies or have contributed to technological development in their regions [14]. Since few academics are working in this field, their importance to institutions' embeddedness in the regions is crucial. These actors are described in this paper as "knowledge brokers". Our aim in this paper is to describe the knowledge brokers as individuals in HEIs. Individuals facilitate the transfer of knowledge between various groups based on institutional strategies and mandates [15–17].

The concept of the knowledge broker refers to the literature of boundary work between science, industry and policy, and communication, translation and mediation work within those boundaries [18,19]. The knowledge brokers can be defined as organisations such as firms, public authorities or associations, and acquire and exchange knowledge to foster competitiveness [19]. In this case, they can be defined as collective actors and as individuals working in HEIs [20] providing knowledge-brokering goals and strategies from different organisational perspectives [19]. Knowledge brokering can be seen as processes, organisations, or individuals that increase or connect relationships, co-evolution and knowledge production between academic actors and other actors in policy processes [21]. Institutions and individuals as knowledge brokers analyse the impact and use of datasets and classify the roles of networks and levels of knowledge and knowledge transfer [21]. The actions of knowledge brokers in the communicational decision-making process must increase effective communication. The literature identifies brokers as third-party members; that is, they are trusted, and they facilitate the knowledge brokerage activity [22]. However, HEIs are still key actors in the transfer of knowledge and enhancing innovation as a part of the knowledge-brokering process [4,23]. In this regard, we will define the knowledge broker's role in the concluding section. There are many alternative frameworks to define knowledge brokers in publicly funded organisations, but knowledge brokers have often been undefined or unrecognised [17].

The knowledge broker's role includes a broad range of activity, and they are seen as actors in the system framework, focusing on knowledge production, management and passive communication. The knowledge broker's most important role seems to be being in charge of the knowledge production and valorisation process, in which knowledge is not transferred but is valorised (redefined and valued) into a format to be utilised in another context [16]. The result of a knowledge broker's efforts might be financial, but in the case of a HEI it can also be an operational model that strengthens the institution's role in society and its service practices. A result of knowledge brokering can be support for evidence-based decision-making or other utilisation of knowledge. Thus, the main product of a knowledge broker may be the legitimacy of the HEI. Indeed, knowledge brokers can be described as knowledge exchange professionals, often associated with work conditions, casualisation and performance management demands [15].

In the knowledge broker position, HEIs would be able to develop smart specialisation actions that support the program objectives, but also enhance the development of the knowledge society. HEIs have access to global knowledge sources, as well as national and regional sources, so they can recombine and enhance knowledge diffusion for multiple needs. In networks, knowledge brokers acquire knowledge from partners in their network more often than from partners without knowledge broker positions [16,24]. Smart specialisation activities are embedded in a fundamental role of HEIs, but with particular emphases. University—industry linkages and the HEI's core role are naturally formulated in the S3 process, but with the knowledge broker role it is possible to add impetus for HEIs to promote future policies, and to increase the use of the knowledge which has been embedded in regions and largely in public and privately funded institutions [25].

There is growing evidence that HEIs have adopted the role of knowledge broker [26]. This role is even defined as a sign of a postmodern profession which has links and embedded institutional connections to platforms in the innovation process. Especially in the regions, with the absence of large firms, there is a growing need for public knowledge brokers [11,13,16,26,27]. The Smart Specialisation strategy will provide empirical evidence of the manner in which these phenomena can become more collaborative and more visible.

In regions with major industries, entrepreneurs are often found in the role of knowledge broker. In smart specialisation programs, HEIs have a role that can be defined as being a knowledge broker for regional, national and international actors. These roles are crucial, mostly because other organisations, including industry, are not in direct contact with each other. The HEI's role is based on collaborative actions, the trust of society, and the engagement of stakeholders for cluster building [28]. As research has shown [29], currently it is important for HEIs to increase the emphasis on the wider usefulness and uptake of research, which will increase the mobilisation of knowledge and enable the emergence of innovation.

2.2. Creating a Sustainable Knowledge Society

In contrast to the industrial economy and competitiveness, the knowledge society focuses more on the production, valorisation and the usability of knowledge in different contexts [12]. Knowledge enhances actors' understanding of drivers for the future, in which knowledge, research and education, as well as human capital and new technologies, are the components shaping the knowledge society [30].

Integration policy in the EU can be accomplished by reforms and implementation projects which also enhance the functions of the knowledge society. From the perspective of European higher education policies, the European-level integration policy and knowledge society policy have enabled new development conditions. The underlying idea was to increase the competitiveness of Europe by building an innovation-sensitive society with common rules for the welfare society [31] (p. xxxvi).

A key level of analysis in this paper is the HEI as a knowledge-based organisation. Individuals working in HEIs are engaged in their own institutional structure, and HEIs are embedded in broader systems such as national innovation strategies and networks [32]. In this way, HEIs also strengthen the legitimacy of their activities by supporting companies and knowledge-using organisations both regionally and locally [14]. A key element for implementing the embeddedness of HEIs in their urban and regional surroundings is achieving mutual benefits [33]. In this regard, the Smart Specialisation Program highlights the roles of individuals and institutions as knowledge brokers. Competitiveness and internationalisation are the policy goals of smart specialisation and goals for HEIs. Regional collaboration and cluster strategies are also important for HEIs, because they embed HEIs tightly into the regional structure, leading to significant investment [34].

In this paper, we find universities and universities of applied sciences to be actors in national innovation systems. The system of universities of applied sciences was being formulated in the early 1990s, and, since then, their foci have been on teaching and regional impact. The Polytechnics Act (2013) in Finland strengthened their role in research, and several mergers with universities have legitimised their role in the innovation system. The Universities Act (2009) emphasises universities' role in national and international research systems, and their role in teaching and societal impact. The third key actor in the research sector in the Smart Specialisation Program comprises research institutes, and they have a key role in sector research and a major regional impact [35,36]. In the Finnish case, their regional role and contributions to the regional economy are the driving force behind innovation. From this angle, HEIs have a special regional mandate, referring to legitimacy which is based on factors related to economic growth and well-being. The strong regional impact also provides a possible role for influential individuals as academic entrepreneurs [9,28]. In Section 4, our analysis recognises the role of knowledge brokers in particular in this context.

Strategies to increase universities' competitiveness have changed their focus to emphasise the creation, transfer and application of knowledge. R&D actions, the application of knowledge and the ability of higher education to create and transfer knowledge have especially been a central focus for the development of ideal institutional profiles [37,38]. Competitiveness-related institutional strategies have changed the nature of the knowledge required. Stronger emphasis on R&D actions based on scientific grounds is seen as a key factor accelerating economic growth and persistence.

HEIs are key actors in developing wealth in society and the knowledge economy. The role of HEIs is as key players in knowledge production, and their entrepreneurial mission as players in the

Quadruple Helix for science and knowledge [39]. HEIs are strategising their activities to fulfill wealth creation demands in society by co-creating activities. In general, the role of HEIs in the regional innovation system is necessary because of the longstanding experience and embeddedness of funding systems and international research systems, as well as the experience of developing framework programs [40].

The importance of HEIs can also be seen from other perspectives. Firstly, their role as active knowledge brokers encourages institutions to change their structures and networks to be more innovative in a way that increase innovativeness and long-term relationships in national innovation systems as well as in global innovation networks [7]. Secondly, the mission-oriented universities face many demands from society. The development of a knowledge society requires the fulfillment of certain expectations, such as funding models when regional and international networks are seen as a requirement for effective action from universities. This connects universities more closely to society [29].

The literature on the role of HEIs in innovation systems points out the importance of knowledge-brokering actions. Without these actions, there is a risk that innovation activities will not be based on scientific knowledge. The academic knowledge produced is used for other purpose and not for local networks [16]. From the regional perspective, the absence of university knowledge brokers refers to the lock-in discussion of the need for knowledge transfer, management and linkages across borders as a mix of specialised regional knowledge and globally dispersed knowledge. These are crucial for solving the problems of inflexibility in the innovation system and enhancing the potential for innovation. In the end, all these problems reflect the political achievements and the evolution of smart specialisation, as well as increasing the use of knowledge and the absorptive capacity of enterprises. These activities reduce the sectoral differences between industry and HEIs and can create a more common regional future based on shared visions and the in-betweenness of sectors; they can also create sustainability [5,13,24].

3. Materials and Methods

The data in this paper were collected from the implementation project of Smart Specialisation strategy- Arctic Smartness Excellence project (ASE) in the Lapland region of Finland. Smart specialisationin Lapland is based on the Arctic Smart Specialisation strategy that was published in 2013 [41]. Smart specialisation is based on cluster activities, strengths, value chains and new forms of cooperation in the Lapland region. The analysis of multiple projects and the strengths of the industries are the basis of the construction of five clusters. The construction of clusters is mostly made by regional authorities, research organisations and HEIs, and actions are based mostly on public projects.

For this paper, documentation on smart specialisation and interviews have been examined. The data include 20 interviews with key actors in regional smart specialisation, including cluster managers, members of the program board, management of the participating organisations, officials of the funding organisation and representatives of the enterprises. Actor groups in Arctic Smart Specialisation are clearly identifiable, and for this reason the organisation has not been named, but the interviewees' gender and status in the organisation have. The topics for the semi-structured interviews were knowledge, collaboration, leadership and the role of companies in Arctic specialisation.

Interviewees were selected according to the structure of the ASE project. Partner organisations had their key actors in project roles in the clusters or work packages of the project. Also, some interviewees were selected from outside the project in order to provide more holistic perspective of regional development and innovative actions based on funding instruments. Because the clustering is at an early stage in Lapland, only three participants from companies belonging to the cluster were selected. The core parameter for selection was that interviewees were leaders of the program or clusters, members of clusters or work packages, funding agencies or companies related to cluster activities. The organisations, their roles and the contribution of the interviewees' are presented in Table 1.

Table 1. Organisation and role and contribution of Interviewees'.

N	Organisation	Role	Contribution
4	Regional Council of Lapland	Members of the program board, funding authority, developer organisation	Creation of specialisation, S3 participation and implementation, actions relations to policy instrument, subprojects and thematic platforms
2	University of Lapland	Project and cluster management	The direction of the project, coordination and development of Arctic design cluster
4	University of Applied Sciences	Cluster management and member of program board, developer organisation	Coordination and development of Arctic safety and Arctic development environments clusters, relation between specialised areas and funding opportunities
3	Centre for Economic Development, Transport and the Environment	Funding authority, network and innovation cooperation	Clusters vs. innovation project, cluster building and regional strengths and funding
2	Rural advisory services	Cluster management, developer organisation	Coordination and development of Arctic rural network cluster, cooperation with entrepreneurs
2	Development centers	Cluster management and program collaboration, developer organisation	Coordination and development of Arctic industry and circular economy cluster, value chains and cooperation with companies
3	Representatives of enterprises	Emerging industries, organisation of entrepreneurs and company collaborating in cluster activities	Needs of entrepreneurs, needs and future directions of health sector, willingness of companies to join cluster activities

The data were collected between December 2016 and February 2018 and include an estimation of the regional actors' investments in the realisation of smart specialisation objectives. The data for this paper were based on the program documentation and interviews with representatives of Research and Innovation Strategies for Smart Specialisation (RIS3) implementation in Lapland. The document analysis also included the perspective of the ERDF funding instrument for the ASE program and definitions of the smart specialisation clusters. The data from the ERDF funding instrument shows the number of projects funded by the ERDF in Lapland in 2016, and therefore complemented the interviews and constructed the basis for understanding the capacity building and other needs of the region.

The analysis was carried out using NVivo software, using qualitative content analysis to have a flexible but systematic analysis of the role of universities in smart specialisation. The analysis was based on analytical concepts (nodes) of network cooperation, knowledge capacity, the role of actors and project management. Nodes were combined into the main nodes and subnodes were created under each main node previously introduced. Subnodes were decision-making, control and roles in decision-making bodies, prerequisites for continuity, the role of companies, the needs of the companies, the roles of public organisations and subgroups, competence and knowledge, the growth of competence and effectiveness, as well as change with cooperative network actions. NVivo subnodes are categorised between those having something in common [42] (pp. 105–106). Four key themes of defining knowledge brokers were created by generalising the subnodes and they are cluster building, decision-making and control, the social dimension of networks and exchange elements. Themes have been introduced in the conclusion section, and those themes introduce the four dimensions of knowledge brokers in the case networks.

Even though the analysis for this paper was based on concept-driven content analysis, the data had the most important role in creating the subcategories, and the coding frame itself provides a comprehensive description of the data collection [43] (pp. 170–173). The analysis of the networks revealed the functional opportunities that could be provided by the clusters, and the results of the program have been verified by the concepts of external effectiveness, reflexivity and societal interaction and the interpretation of knowledge brokers.

The data provided information on building knowledge as capacity for the key actors, and the support of the program in terms of funding, competitiveness, digitalisation and sustainable development of the environment. The purpose of these perspectives is to make the strategic priorities and effectiveness visible. Regarding external effectiveness, the criteria should be clarified for openness and locality. Transparency refers to changes in work practices that improve the ability to achieve goals. Locality refers to activities that support the construction of clusters that are linked to the capacity-building functions of the regional actors. The criterion of external effectiveness is based on the smart specialisation monitoring definition, which emphasises learning, trust and accountability [3].

4. Analysis

The smart specialisation funding instrument is configured here in line with cluster policies, which were carried out purposefully and were formed with the evaluation of research and innovation policies, joint platforms for dialogue, the coordination of research and innovation policies, and cross-border research and innovation strategies in mind. HEIs can play a key role in the institutional frameworks founded for the formation of clusters, and society has major expectations of the role of these institutions to control information and practices to build a successful cluster policy.

4.1. The Role of Actors

Based on the interviews, it seems that the objectives of the program and the expectations of the actors did not intersect. The problem appears to be with the incompatibility of the defined program goals and the expected results. This can also be influenced by the structural basis of the program. The clusters have been primarily created by publicly funded organisations, making the role of HEIs even more crucial:

> *"In this case, the enterprises are mostly not participating in the clusters, as we have built up the background for their participation. There are more civil servants and researchers and sympathisers of these clusters. This situation has been necessary, and it has taken a lot of time to reach. The clusters' development stage varies a lot."*
>
> —representative of the developer's organisation, female.

The cluster work with companies is still at an early stage in Arctic Smart Specialisation. Based on the data acquired for this paper, the engagement of companies may vary and their intention to belong to a specific cluster is still unpredictable. It seems that some companies do not find international funding to be attractive. For example, tourism entrepreneurs and forestry operators have an identifiable threshold for launching or participating in EU projects. It is still unclear which decision-making companies engage in clusters and what rights and obligations attached to the network will follow:

> *" ... most of the micro enterprises are not interested in . In these kinds of projects, it should be able to demonstrate the measures much more clearly directly to those enterprises you want to make results ... must show the resources that are either financial or human resources to help enterprises to the internationalisation and growth."*
>
> —representative of developer's organisation, male.

The knowledge brokers' role can be seen as being innovative leaders of the regional innovation system. The work involves formal and informal meetings with local and international stakeholders, especially making connections with thematic platforms, finding new projects, funding or partners, or finding new technological or market opportunities, which also refers to the idea of higher education as a postmodern profession [26]:

> *"There have been education activities and there has been knowledge dissemination on funding programs. We give advice and make comments, for example, on how certain ideas of organisation fit with specific funding programs."*
>
> —representative of developer's organisation, female.

The above quotation is an example that shows that the knowledge broker's role is to discover and produce interactive and new information about the activities which will empower actors from various sectors. The quotation emphasises recent scholarly findings that show the importance of public institutions as connectors in regional innovation systems [1]. Knowledge brokers develop funding proposals and connect partners from a range of levels and areas. Knowledge brokers' interactive role can be found as communicators and supporters for the regional and international needs of stakeholders:

> *" ... there are also actors without previous experience of working in international projects but get an opportunity as a member of the cluster. They finally were part of a very large network for this purpose."*
>
> —representative of developer's organisation, female.

This is a core task of knowledge brokers, and as supposed, many companies willing to grow need connectors from regional networks to link local and global knowledge sources [5].

Based on the interviews, the overlapping roles of actors have led management and decision-makers to become confused. The members of the steering group and the members of the project leaders' group have overlapping roles that have an impact on project dynamics. The different roles undertaken by the same actors are caused by tasks and mandates based on the division of work between the member organisations of the consortium, and from various communication practices.

4.2. Network Cooperation Model

The knowledge broker's role in social networks is quite valuable regarding social capital effects rather than empirical indicators [23]. To differentiate between the HEIs, the authority structure should work well and in a proactive fashion [44]. This is not always the case, and external actors are needed to ensure fairness and the predictability of performance. This looks like a task for knowledge brokers.

There is a clear need for the clusters to form a dynamic network mode of action. This perspective also allows for a more active communication of information, for example, through the location of information, and thus becomes part of the actual knowledge broker's role [29,45]:

> *" ... If they are to receive public support, then their clusters must be so closely coupled that it would not matter if I contacted any cluster member or guide (any of them) down the path towards direct European funding."*
>
> —civil servant, male.

Large- and medium-sized enterprises are broadly socially networked, and their needs are more evident than small- and micro-sized enterprises. Interviewees from these enterprises discussed the need to develop a role in the regional innovation system that is related to the pursuit of non-international efforts, such as access to valuable information on markets and investments.

Discussion about knowledge brokering emphasises the natural, embedded role in the innovation system which makes it possible to organise and connect new and old connections to regional needs. [21]. Overall, participants indicated that the solution for the management and decision-making processes would be strong and committed management that coordinates the processes of all the clusters and adapt information:

> *" ... the management system of all the clusters should be professionalised for the organisation with a longstanding experience about international operating environments."*
>
> —representative of developer's organisation, male.

From this perspective, the knowledge broker's role is an opportunity for HEIs to enhance smart specialisation program goals and regional development [25].

Universities offer a lot for the smart specialisation program as knowledge brokers in cluster building. Many of the problems of organised cluster activities have connections to an unclear governance model. For example, cooperation in clusters varies widely. None of the cluster businesses have information about smart specialisation and belonging to the cluster, which raises a problem about how to transfer benefits to the region and companies:

> *" ... there are multiple needs for internationalisation for example sharing the costs and support. It would be important for someone to be able to search networks in advance and matchmake companies ...*
>
> *Unfortunately, the information about cluster work and possibilities has not reached our business."*
>
> —entrepreneur, male.

The above quotation emphasises the role of knowledge brokers. The implementation of programs should work as an interactive process between entrepreneurs, organisations and policy-makers based on their needs. It is notable that the task of a knowledge broker seems to include mapping and experimenting with opportunities and risks as well as needs.

4.3. Knowledge-Capacity Building and Effectiveness of Actions

Regional smart specialisation clusters have been built on the needs of business sectors, but confusion comes from a situation in which several companies are connected to several clusters and the construction of the clusters is too directly based on a sectoral starting point. As an alternative, a more functional starting point could be considered. Research and development actions are widely used and implemented actions in HEIs, but not in all companies, especially small companies [37,38]. In sparsely populated regions, unmanned micro-enterprises may be a challenge for regional effectiveness. In this regional case, for example, tourism is a strong actor, and the sector companies are often small companies that are not willing to open their business concepts to international markets. Their interest in forming a tourism cluster without separate functions is low:

> *" ... there is a need for more functional clusters. And clusters where it is possible to"surf" based on your own needs ... for example if a company needs more information about internationalisation etc ... "*
>
> —representative of entrepreneurs, female.

A functional starting point would clearly support business needs such as development, internationalisation and joint marketing channels. As has been outlined in earlier studies, the mainly public funded institutions like HEIs in Finland have an identified role to act between companies and international markets. Small- and medium-sized companies do not take the role of knowledge broker, as pointed out in the case example [4,46]. The role of HEIs as knowledge brokers is similar when discussing the sectoral and functional starting points of clusters, and this role is similar in cluster networks:

> *"Around the universities, research institutes and development organisations, there are many companies so close or sharing the same activity that they do not think about how close they are to clusters work. If our starting point is to build functional clusters, we have to pay more attention on their interaction."*
>
> —civil servant, male.

The quotation above reflects upon the needs of the interaction and emphasise the role of knowledge and the ability to fulfill the weaknesses of the innovation system with the knowledge-brokering function [47,48].

It seems that the operational benefits and incentives can be built in cooperation between the providers of project funding and the companies [3]. The companies' engagement in long-term cooperation will be a key issue with these companies, as in the short term, the evidence of effectiveness is seldom visible. For example, the project has produced around 30 new internationally funded projects, double what was in the project goals. Their effectiveness and coverage within companies has not yet been verified.

Businesses and publicly funded organisations may have expectations of clustering that is based on a different time span. The knowledge brokers in HEIs play a significant role in meeting the needs of industry, higher education, development organisations and stakeholders. The higher education knowledge broker role is a valuable resource for increasing the institutional autonomy, building the capacity and developing a knowledge-change strategy for the HEIs [49]. Knowledge capacity can vary, and, for entrepreneurs, indirect and tacit knowledge of investment or cluster activities means more than just general information, and makes the regional embeddedness of universities as knowledge brokers even more important to smart specialisation. [5,7].

4.4. Decision-Making and Control

Based on the interviews and other data available, operators of smart specialisation have many simultaneous tasks related to decision-making, implementation and planning. This is partly due the fact that knowledge is focused. The interviewees emphasised that the commitment and the opportunity to commit to the program activities required tangible justification of an organisation's management of the usefulness of the operation. The various organisations and levels of government seem to require the benefits and results of the project to be justified by way of examples to strengthen national cooperation and to drive the joint strategy forward, and a more robust commitment. The knowledge broker concept focuses on network actions, but according to the European University Association [50] and our interviewees, there are multiple needs and challenges [51] to develop multilevel governance through knowledge-brokerage actions in smart specialisation:

> *" ... the activity depends on the mandates to act we have ... Companies without management at the regional level must have the ability to commit to the cluster actions from higher levels of management ... We need to give practical arguments to managers, about what the goals and intended results of smart specialisation based cluster work are."*
>
> —representative of developer's organisation, male.

The network's stability requires that the decision-making is made with organisations that are actors in smart specialisation. The key players are national, European or global companies, or organisations operating in large markets. From the corporate perspective, this highlights project management and directs attention to external communications and the ways in which it is possible to join clusters, and what are the benefits of joining.

The overall picture that emerged from interviews with a network model was based on the various needs of companies. This result is a chance for knowledge brokers to enhance the capacity of cooperation at a regional, national and international level. A joint agreement and understanding of the dynamics are key for enterprises to engage in smart specialisation [12].

Knowledge brokering includes three main features: information management, information exchange and capacity building [13]. Sustainability and the creation of a sustainable mode of operations are significant when describing the HEIs role as knowledge brokers in smart specialisation. The essential benefit of the cluster network is the opportunity for internationalisation, which appears to be an interesting way forward for some companies. The role of knowledge brokers is crucial on this point, because the paths of internationalisation and regional development are not yet entirely clear, and the cluster actors must therefore have a range of opportunities to attach to internationalisation. The problem is that the S3-funded thematic partnership agreements with operators may not relate to the clusters, while the benefit might remain narrow. In addition, the simultaneous roles of actors as implementers and developers, and also the role of authorities, reduce the chances to profit from the benefits of internationalisation. The actors hope for a clearer understanding of how international efforts promote regional impact, the benefits it provides, and how the benefits are returned to the area [5].

In this paper, the role of HEIs as knowledge brokers has been defined through four themes. The role of the actors is not completely clear in smart-specialisation-based projects. There is a clear need for a knowledge broker who encourages and guides internationalisation activities. This work for capacity building is a well-known but sometimes forgotten phenomenon in smart specialisation [5,7,44]. Creating common rules and decisions based on regional need, not only internationalisation, is a task for the knowledge broker. This as well as knowledge capacity emphasises the embeddedness of knowledge brokers and the starting point for clusters [7,52]. Decision-making and control refer to the common understanding and legitimisation of S3 activities. Without a common understanding of the mandates and actions, there is no common future in developing smart specialisation. Information management and the creation of a vibrant atmosphere seems to be a core task for universities as knowledge brokers [5,7].

5. Discussion

Our task in this paper was to outline the role of HEIs as knowledge brokers in smart specialisation and define how knowledge brokers can increase the competitiveness and internationalisation of regions through data which have been collected as part of the implementation of the ASE- project on smart specialisation (Figure 1). The authorisation status of individuals as actors is based on the legitimacy of the HEIs. Without HEIs, individuals cannot play a legitimate role as knowledge brokers. An actor's position is to fulfill the needs of the institutions and the institutions' goals, but as individuals as well as institutional knowledge brokers, they also benefit from their position. The starting point for the implementation project on smart specialisation was innovative, intelligent, constructive and complex. The aim of smart specialisation is regional development, and it requires the beneficiaries of the activity to recognize the potential of new operating models. Defining the benefits and responding to needs should turn to the conscious benefit and involvement of the beneficiaries. The conscious strengthening of the beneficiaries' own activities requires a more extensive role for management and the steering group.

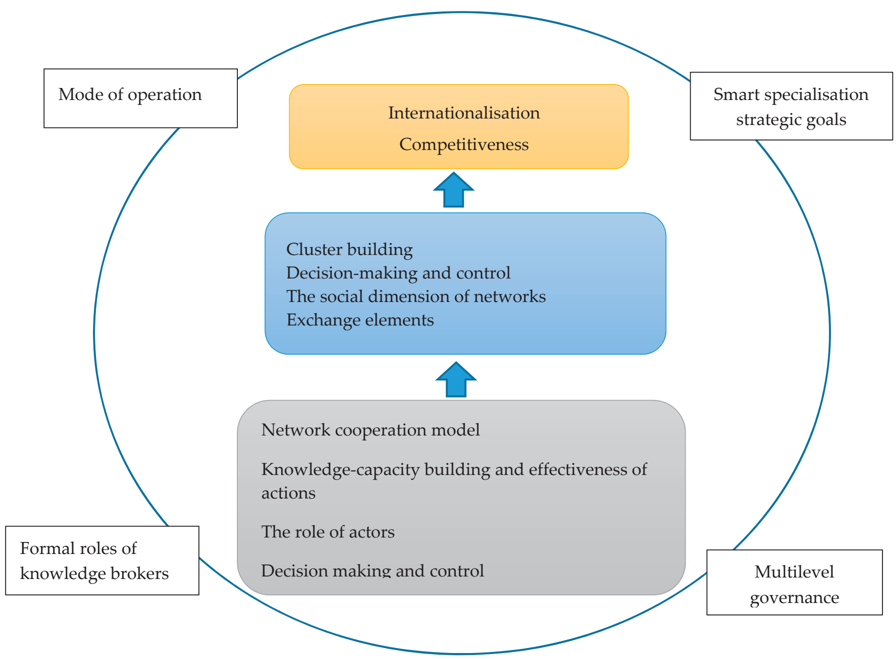

Figure 1. The key themes of defining the knowledge brokers' role based on the data of the regional smart specialisation program, Artic Smartness Excellence (2016–2018).

According to the European University Association, HEIs can play an important role in the formation of multilevel governance models based on a smart specialisation strategy [50]. Based on the interviews conducted for this paper, the strengthening of this role requires clarification of the knowledge broker role, which can be promoted from four perspectives. First, achieving effectiveness goals can be verified with regard to the smart specialisation strategic goals achieved. The projects produce many unexpected and unpredictable results, which at best also support the strategic goals of the project. It is essential for the region's businesses and developer organisations to be in a position to know the smart specialisation actors' roles. Clear business practices and tasks create the prerequisites for enterprises to be aware of the future opportunities that smart specialisation can pursue.

Second, the case illuminates the way in which multilevel governance takes place in a sparsely populated and Northern regions. Decisions on cooperation between the innovation system actors takes place as informal cooperation. Therefore, these data and interviews indicate that the key areas of multilevel governance are the implementation and funding decisions of the program. Through these instruments, the preferences of the actors are prioritised through project activities. The formal institutional decision-making is a minor role in network cooperation, and very few actors emphasised decision-making to legitimise the broker's role. This angle brings dynamism to the region's clusters and enables industry to operate in multiple clusters. In this case, it was justified for a cluster to change its participants actively and the admission to be kept open. From this angle, the clusters are open and social networks, rather than closed consortiums. The consortiums take place in projects, and the clusters are a platform for closer cooperation between actors. [51,53].

Third, clustering should be organised in a way that the formal roles can identify their tasks and obligations. The funding guidelines and procedures have not guaranteed this. Finland does not have strong regional innovation systems, but the national innovation system is well established. The starting point of the smart specialisation funding instrument is different, as the key actors are the regional councils and the national-level actors have not been actors in the implementation in decision-making. Based on the data gathered for this paper, this financial instrument alone does not establish a regional innovation system. However, in this way, the smart specialisation program strengthens regional decision-making and creates the infrastructure for the regional innovation system. Knowledge broker roles in HEIs can be identified in building this infrastructure. What these knowledge brokers have in common is their focus on regional projects and regional level networks and partners.

Fourth, the obvious way for the knowledge brokers' mode of operation is to be aware of the tensions of the present actors as part of the Smart Specialisation Program. The overlapping roles and the movement of actors between clusters is a natural part of the operating model but should be based on a clearer governance model.

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Training Entrepreneurial Competences with Open Innovation Paradigm in Higher Education

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Abstract: This paper shows the effects of training entrepreneurial competences on employability in higher education. It identifies teaching methods that are more effective in order to improve entrepreneurial competences. These are hackathon, team building, role play, and practical cases with entrepreneurs at a Spanish university. In contrast to the methods shown in previous literature, a mixed-method is proposed. Firstly, a qualitative technique based on three focus groups with the participation of lecturers, students, and entrepreneurs are used. Additionally, a regression analysis seeks links between entrepreneurial intention and employability with entrepreneurial competences with 329 students. The findings show the direct effect on skills appreciated in companies, using collaborative and practical activities focusing on competency perspective. This research work provides a new approach to training entrepreneurial competences that demonstrates the main role of Open Innovation enhancing the main stakeholders' motivation and improving their skills. Useful information is provided to design the academic syllabuses and improve the level of employability of university graduates.

Keywords: Higher Education; University; Entrepreneurial competences; Employability; Theory of Planned Behaviour (TPB); Open Innovation

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1. Introduction

Entrepreneurship is currently regarded as a solution for socio-economic development given the growth of new business worldwide [1]. However, the entrepreneurial intention (EI) of university students has steadily increased but has not yet reached the levels desirable to solve the problem of youth unemployment. This is the reason why regions with the highest rates of unemployment have been experiencing an increase in entrepreneurs in recent years, particularly in the case of the south of Spain [2,3]. Entrepreneurship is considered a transversal competence aimed at increasing employability and adaptability to the job market [4,5]. This is the reason why the reduction of unemployment rates and effective policies in business creation are a priority which cannot be left solely up to governments. In this regard, universities are assuming responsibilities and seeking to involve their multiple stakeholders, in line with their social commitment to some extent [6]. In recent years, youth unemployment has become a major topic that has drawn the attention of policymakers [7] and searching for a solution requires a shift to active employment policies, training, and access to the labour market. Entrepreneurial education programmes are proposed to enhance it and, although this statement is supported by numerous research studies [8–10], further analysis is required to know how training in entrepreneurial competences influences recruitment. There is a consensus that entrepreneurial intention is a personal orientation which might lead to venture creations but measuring this question remains a challenge [6,10], along with tracing precisely how entrepreneurial intention results in businesses set up by people graduating from higher education [11]. Such predisposition could lead to owning a business or becoming self-employed or be the basis for facing professional life with a set of skills related to entrepreneurship. Acquisition of entrepreneurial competences means the ability to recognize and act on opportunities, take initiative, persuade, argue and communicate and apart from that, it implies being able to exploit an opportunity in a specific context, including its management and evaluation [12] Based on this description, being entrepreneurially competent is appreciated in paid employment and self-employed economic activities [13,14].

It seems obvious that students need opportunities to practice what they are learning and obtain experience in the kinds of tasks where they are expected to demonstrate competence in their professional life [15–18]. Therefore, the educational system is facing the challenge of designing activities aimed at achieving higher quality in student learning, overcoming the traditional paradigm at the university, more focusing on the transmission of knowledge and application of procedures [19]. Thus, universities strive to improve employability for their graduates by embedding key competences, which include entrepreneurial skills in higher education curricula [20]. Given the above, the aim of the study is to test the effectiveness of a set of tools designed to improve entrepreneurial competences and compare their results. Fayolle [21] (p. 696) points out that few studies set out to compare the effectiveness and efficiency of different teaching methods used. Overall, there are two main trends: behaviourism and constructivism. Behaviourism assumes learning is primarily the passive transfer of knowledge from the teacher to the student, while constructivism assumes that learning involves actively participating in the construction of new understanding [22] (p. 280). Both have been widely discussed in the literature [22], but there is less evidence about tools, activities and pedagogies associated with them. Specifically, Bechard and Grégoire [23] identified three types of teaching models in higher education: the supply model, the demand model and the competency model, an additionally the hybrid teaching models as a result of their combination. Some kinds of activities are associated with each one. The supply model promotes pedagogical methods leading to transmission and reproduction of knowledge and the application of procedures. The demand model uses activities involving exploration, discussion and experimentation. Finally, the competence model focuses on pedagogical methods that highlight active problem-solving in real-life situations. According to the authors "teaching is conceived as a strategic intervention to allow for—and influence—how students organize the resources at their disposal (e.g., knowledge, abilities) into competences that can be mobilized for action" [23] (pp. 115–116). In particular, this approach used to be related to the acquisition of competences as it seems more suitable for matching graduates' professional profiles to labour market requirements employability [5,6,20].

According to Kolvereid [24], Rae [16], and Sewell and Dacre Pool [20] training competences can be a key factor for business creation but also for employability and, this is the issue on which this paper is built. Entrepreneurial competences as an indicator of being better prepared to face the labour market and professional development are the core of this research. Likewise, an improvement of employability built out of entrepreneurial competences is a new insight in this field.

In this context, a collaborative model in which stakeholders can play a key role could enhance competency acquisition. However, these models have still not become widespread in the educational environment and, they could be a valuable source of innovation and modernisation for universities, especially in combination with entrepreneurship [25]. Nor research has focused enough effort on this line of investigation and currently, there are still few studies with this approach [21] the Open Innovation (OI) approach is beginning to be introduced in order to involve students, lecturers, graduates and companies in decision making. Consequently, motivation and learning and professional outcomes can be improved [26]. This issue has barely been applied in previous literature despite being an opportunity for higher education [27]. Thus, the introduction of OI in this research is a shift from the traditional approach in this field.

On the basis of the above, this research work seeks to respond to three main questions. The first being, can entrepreneurial competences adapt the university students' profile for facing labour market requirements better? The second, what design (contents and methodology) of training activities improve students' skills? The last, what effects do Open Innovation practices have in training of skills in higher education?

This paper begins with a review of the existing literature focused on the Theory of Planned Behaviour (TPB) relating to entrepreneurial intention and reviewing the most mentioned entrepreneurial competences. Both are the basis for designing different training tools and, consequently, they are the focus of the final analysis [28,29]. Secondly, the methodology used is discussed and although quantitative descriptives are included, this research work is developed supported by a qualitative technique. On the one hand, the measurement of the entrepreneurial intention of 329 students from a public Spanish university before and after student participation in training activities and on the other hand, three focus groups in which participating students, lecturers, and entrepreneurs with the support of the Atlas.ti. This choice allows the aforementioned objectives to be reached and the limitations mentioned in the literature to be overcome by focussing on a specific case of students on different degree courses. Thirdly, the most important results of the investigation are presented. The results obtained have contributed to show an improvement in entrepreneurial competences when academic knowledge and passive learning is not the core and the designed activities are based on interaction and, furthermore, when the participants themselves feel more personally engaged and an integral part of the decision-making process. Additionally, the main contribution is a reflection based on a case of study that offers a framework with keys of philosophical and didactical dimensions of education programs focused on entrepreneurial competences. The paper ends with the main conclusions and their implications in the field of entrepreneurship.

2. Literature Review

A proper plan for fighting unemployment should include entrepreneurship as a keystone [7,30]. Governments all over the world are, thus, focused on promoting entrepreneurship. Direct effect on employment, innovation, and growth of the nation is widely shown in previous literature [31–33]. However, as criticised by Goddard and Vallance [34], and Fuster [35], further evidence is needed to show the direct effect and to understand the influence of the environment on these relationships. Policies, funds, grants, and educational programs are some of the facilities executed to support economic sustainability [36,37]. That is, actions and practices aim to support long-term economic goals without having a negative impact on social and environmental aspects. In any case, entrepreneurship should not only be considered as business creation, but would also improve employability and adaptability to the job market [1,5]. Both positive effects draw from entrepreneurship as a transversal competence and, therefore, its training at different degree levels allows students to demonstrate a more adapted profile to labour market requirements. Universities come into the picture for this reason and they have been taking on fostering the entrepreneurial spirit. The incorporation of entrepreneurship in higher education programmes completes the educational and research role of these institutions and fulfils a social role [10,26,38]. Moreover, recent literature suggests that entrepreneurial education programmes improve the ability to discover and exploit opportunities and enhance entrepreneurial intentions [39]. Despite the fact that relationships between entrepreneurial education programme and entrepreneurial intention are shown in several research papers [40–42] there is equivocal evidence. For example, Souitaris et al. [39] found no significant relationship and other studies even suggest an inverse relationship [43,44]. Curiously, some explanations point out that personal abilities and increased awareness of the challenge inherent in starting a business are critical [43]. In this sense, education plays a prominent role in gaining knowledge and competences as well, though further empirically rooted research is needed into what and how entrepreneurial education programmes impact on both [45,46]. This research paper focuses on analysing how training activities affect entrepreneurial intention (EI) and competence profile. Consequently, entrepreneurship is typically studied in degrees linked to the economy and business, to a lesser extent linked with engineering and is practically non-existent in Humanities Degrees. By contrast, there are very few studies comparing groups from different knowledge areas [41,42]. All of those included in this study are precisely an innovation with respect to previous research papers.

The Theory of Planned Behaviour (TPB) by Ajzen [47] supports the analysis in this study. This theoretical framework is widely used in previous literature to approach entrepreneurial intention [9,48–51]. Its robustness becomes an appropriate model to explain the predisposition and intention to set up a business [24,52,53] especially if the focus is on pedagogical processes and learning contexts [9,54,55]. This framing considers three issues: (1) Personal Attitudes, (2) Subjective Norms, and (3) Perceived Behavioural Control, and the result of their interaction has a direct effect on entrepreneurial intention. Although this research paper focuses on these elements, it is undeniable that attitudes are not just a product of cognitive factors. However, external factors should be borne in mind when setting up a business [56]. On the other hand, according to Krueger et al. [54], and based on models by Shapero and Sokol [57], and Ajzen [47], internal traits and external aspects (socio-cultural factors) could be moderated by the learning process and the entrepreneurial competences could be improved as a consequence of this [29]. A degree of consensus now exists concerning entrepreneurial personal traits and skills in literature. As a result of this, creativity, risk-taking, proactivity as an entrepreneur in the internal dimension, and entrepreneurship image in the external dimension are highlighted. Mitchelmore and Rowley [28] emphasized the relevance of establishing an agenda for future research and experiments in relation to entrepreneurial competences and their implications on economic and social development. With this in mind, several research papers [14,29,43,58–61] Morris et al., [62] analyse how the aforementioned entrepreneurial competences have influenced entrepreneurship.

Finally, it should be emphasized that this research work overcomes the gap referred to in the literature. The lack of common knowledge and evidence about didactical, pedagogical dimensions, and performance of entrepreneurial education and teaching [19,21]. Even less attention was paid to the competence-based approach.

To address these questions, we have formulated a series of working hypotheses:

Hypothesis 1.1: *There is a crucial relationship between creativity, risk aversion and proactivity and entrepreneurial intention.*

Hypothesis 1.2: *A link exists between entrepreneurial competences: creativity, risk aversion and proactivity and the improvement of perceived employability.*

Hypothesis 2: *Entrepreneurial intention (EI) depends on the following factors:*

H2.1. Creativity (C)
H2.2. Risk aversion (RA)
H2.3. Proactivity

Hypothesis 3: *The improvement in perceived employability maintains a dependence relation on the following factors:*

H3.1. Creativity (C)
H3.2. Risk aversion (RA)
H3.3. Proactivity

The hypothesis related to entrepreneurial intention and entrepreneurial competences are on the lines of that mooted by research works like. This issue has been widely discussed in general terms by Morris et al. [62] and Arranz et al. [63]. Both reflect and provide some evidence over the potential of a competence-based approach on entrepreneurship education. Likewise, there are numerous research papers that pay attention to how competences affect to entrepreneurial intention [4,14], while other research works specifically adjust their focus on entrepreneurial competences [10,29,43]. Even, some authors adjust their fieldwork to one or a group of entrepreneurial competences.

For example, Crant [58] and Uy et al. [60] deepened in proactivity, while Sarri et al. [59] designed their study highlighting creativity and innovation as main entrepreneurial competences. In this case, entrepreneurial competences more referred in previous literature are the basis of the hypothesis. Therefore, the insights provided are the result of this different vision in the entrepreneurship field.

By contrast, hypothesis 1.2 and 3 focused on employability and entrepreneurial competences provide insight from its own approach regarding previous literature. It is possible to find out two types of studies. On one side, those focused on the contribution of competences–not only entrepreneurial competences–in employability [18]. On the other hand, research works as Machin and McNally [6], Dacre Pool and Sewell [64], but both are mainly series of reflections in which some proposals for researchers and policymakers can support their decisions. Thus, the scarcity of reliable, complete and up-to-date evidence on this issue (entrepreneurial competences and employability) is identified as the source of main insights in this study.

Open Innovation in Higher Education

The discussion of what form Higher Education should take to generate knowledge and provide professional skills remains open. UNESCO [17] (p. 3) points out that "education tailored to current need implies transcending academic knowledge and passing from the student's passive learning to a conception where learning is interaction and it is built among all". Consequently, universities try to design activities aimed at achieving higher quality in student learning, overcoming the traditional paradigm. In this scenario, Open Innovation (OI) introduces a new perspective. This paradigm means listening to all stakeholders as a source of knowledge and, consequently as a resource of innovation and competitive advantage. Therefore, OI develops positive dynamics in self-empowerment and allows the stakeholders (mainly, students, lecturers, decision-makers in universities, and entrepreneurs) to generate confidence in themselves and participate actively in building a modern and engaging image of the university. Chesbrough [65] introduced the concept in 2003 and, since then, it has been analysed in different contexts, but particularly the educational environment is an issue where a great deal of further development is still needed. In recent years, the benefits of embedding an openness philosophy in learning based on collaborative knowledge have been widely discussed in the literature [25], but not yet on the desired scale. Social innovation in education is possible due to a collaborative model [66]. In this sense, although recent empirical reviews [45] suggest a positive relationship between participating in an entrepreneurial education programme and developing entrepreneurial intentions, currently there is still insufficient evidence to support or refute this statement. OI in the industrial sector has drawn more attention than in other sectors, such as services [67]. This is particularly striking in the educational environment [26]. Therefore, the lack of empirical evidence regarding innovation and the educational institution is the reason for this research and is the main new aspect. Moreover, whether the numerous benefits linked to OI [68] are transferable to the educational environment can be tested. The implementation of OI can also benefit organisations [69] and higher education institutions can thus find an opportunity to engage with stakeholders, especially with students, and to portray a positive image to society, exactly as stated in the three focus groups targeted in this research work. Currently, the shortage of empirical evidence obtained so far in the study of OI from this perspective is a deviation from customary practice in this field. Chesbrough [65] claims that sustaining performance in an increasingly complex world requires confidence in this paradigm. This novel instrument is expected to increase in the educational environment, and it will pose a growing challenge in the coming years. It seems a logical step, as is actually happening in other fields.

In the field of Open Innovation, the qualitative techniques are mostly used [67] because it is especially suitable to deepen these assessments, the extent, scope and nature of these practices [27]. For this reason, the Open Innovation approach in this study, is analysed through qualitative techniques.

3. Method

3.1. Measures and Instrument

The entrepreneurial intention, before participation in activities for entrepreneurial training, is measured using a questionnaire modelled on the aforementioned Theory of Planned Behaviour [47]. Its strength as a framework in the development of research in this field, as well as its explanatory capacity according to the literature reviewed, justifies this choice. The questionnaire was divided into four blocks: I. Personal Attitudes (PA) consisting of five items, II. Subjective Norms (SN) consisting of three items, III. Perceived Behavioural Control (PBC) with six items, and IV. Entrepreneurial Intention (EI), measured with another five items. A scale of seven points (Likert scale), with 1 expressing the strongest disagreement and 7 the highest level of agreement is used to analyse each one of them.

Once the different training activities have been completed, a combination of a quantitative technique and qualitative technique is made. The purpose of this choice is to gain a better understanding of connections or contradictions between qualitative and quantitative data, which can provide opportunities for participants to have a strong voice and share their experiences across the research process.

The carrying out of this study necessitates a mixed-method approach, the novelty of the analysed field and the research questions raised require this type of method due to their complex nature [70,71]. The quantitative methodology was useful to test Entrepreneurial Intention before and after implementing four types of activities for training entrepreneurial competences as well as the improvement of employability perceived by students. Secondly, the qualitative methodology based on three focus groups was used to design the training competences, approach in understanding how interactions occur and the specific contributions of stakeholders. Finally, we used the concurrent triangulation strategy to cross-validate the two databases [70,72]. Specifically, Cai [71] highlights that the general purpose for conducing qualitative and qualitative method in higher education is to gain a fuller understanding. Papadimitriou, Ivankova, and Hurtado [73] (p. 2) "point that integration of methods helps ensure more rigorous studies and better transferability of the generated conclusions". It has tended to become an excellent option to approach the research topic and has increased in higher education. This study utilized a sequential explanatory design [74] consisting of two phases. Thus, the data from the focus groups could help explain the quantitative results provided by regression analysis for the purpose of complementarity [75]. The data were connected, and the quantitative phase helped inform the qualitative phase. The results were connected to gain a better understanding of the findings from both phases. Consequently, firstly a regression analysis supported in a questionnaire designed to show entrepreneurial competences related to entrepreneurial intention and the improvement of perceived employability is applied. Secondly, three focus groups, one for the lecturers involved and two more for students, is organised to evaluate which tools and resources to train competences related to entrepreneurship are better. The choice of regression and focus group deserves further explanation. In one side, a multivariate analysis technique: linear regression is used because it allows testing the influence and the relationships between main issues [76]. In this case: entrepreneurial intention and employability. This type of analysis is suitable for explaining the extent to how these variables are connected with training of entrepreneurial competences, as well as its predictive ability. On the other hand, focus groups are viewed as the proper qualitative technique due to the exploratory nature of the study and it is a way to identify and report the feelings of a heterogeneous group. In discussion situations, some understanding of issues, concerns and experiences of the people involved is gained [77]. As a result of this, the regression analysis applied in combination with focus group allows identifying omitted variables, unobservable factors that only can be identified through a qualitative approach. Both works perfectly together, one to test quantitatively the proposal model of relationships and the other to contrast based on deepener qualitative details. According to Newman et al. [78], this methodological choice serves to generate new knowledge and test new ideas.

The design of the questionnaire includes five blocks. The first three: creativity, risk aversion, proactivity corresponding to the entrepreneurial internal dimension [14,58–60,79], and entrepreneurship image is the main item regarding the external dimension, [61] and, finally, the five items for measuring entrepreneurial intention in TPB model are included again. Finally, an item about the improvement of employability is introduced to measure it in connection with entrepreneurial competences. The same scale of seven points is followed.

3.2. Data Collection

The public university in southern Spain chosen represents a valid approach to developing the study because it has been striving to showcase entrepreneurship as professional development for the last two decades. Moreover, this university offers a complete ecosystem with programmes to enhance entrepreneurial spirit, incubators, accelerators, contest of business creation, challenges with enterprise participation, events and forums, mentoring programmes, etc. It should be emphasized that the chosen university belongs to a region with the largest population in Spain [80] and it is mentioned as a key knowledge agent and one of the strengths of the R and D system together with the Technological Park and the Innovation Centres. Initially, it can represent higher education institutions and be the first case of study in this field. Additionally, it is a medium-sized university that it can be regarded as just representative with regard to public higher education, especially in Spain.

The fieldwork lasted four weeks and it was geared towards 329 students from any degree and from different centres belonging to a Spanish public university. The distribution of the sample by degree is in line with the number of students in each area of knowledge at the University of Malaga. They participated at the same time in the programme. The criterion for choosing these students was that they were on university degrees which included specific courses in business creation. In any event, special emphasis has been placed on finding an equal representation of Business and Management, and Non-Business and Management. As a result of this, the type of random selection has been cluster sampling. The entrepreneurial intention from the TPB Model and entrepreneurial competences linked to entrepreneurial intention were measured in the same students before and after their participation in four types of activities for training competences: role play, team building, solving real case studies with an entrepreneur, and, finally, a hackathon. They were all based on problem-solving linked to entrepreneurship. It must be pointed out that these activities were linked with entrepreneurial intention, but it is still not sufficiently analysed from the perspective of employability despite valuable related competences. This is precisely why the measurement of the improvement of employability is introduced in the questionnaire. This item, the students' personal evaluation is only answered after the participation in the training activities. This is one of the main limitation that will be pointed out in the final section, but it is simply intended to highlight the potential of training entrepreneurial competences on their self-confidence. However, the qualitative approach provides additional details about employability introducing the point of view of lecturers and entrepreneurs.

Then, there is a more detailed explanation of each activity in order to understand the underpinning concept of the initiative better. Moreover, Table 1 provides detailed information about the methodology and the pedagogy of each learning tool: duration, technical and human resources, and spaces, etc.

- **Hackathon.** This is an activity focused on solving practical problems that continues for a long time and requires a great deal of energy, patience, or determination, and requires the combination of participants with different profiles who generally do not meet each other beforehand.
- **Team Building.** The action or process of causing a group of people to work together effectively as a team, especially by means of activities, events designed to increase motivation, and promote cooperation focusing on a common challenge. There is competition between groups.
- **Practical Case with an entrepreneur.** A case study is a learning method involving an up-close, in-depth, and detailed examination of a subject of the case, as well as its related contextual conditions. It has a real solution, but the participants do not have this at the beginning, and they can work together in searching for proposals before finding the real solution and its consequences.

- **Role Playing.** This is a technique that allows students to explore realistic situations by interacting with other people in a managed way in order to develop experience and trial different strategies in a supported environment. It is a way of working through a situation, a scenario, or a problem by assuming roles and practicing what to say and do in a safe setting.

Table 1. Technical details of training activities.

Participants	Duration	Space	Groups	Technical Orientation	Human Resources
Hackathon: Plan and design for the next entrepreneurs fair and work in dossier for attracting sponsors					
Participants	**Duration**	**Space**	**Groups**	**Technical Orientation**	**Human Resources**
80	The whole day	Outside the university in entrepreneurs fair	8	The groups compete against each other with a common challenge. There was an award to motivate more (collaboration of sponsors).	4 Lecturers 2 Coach (two external collaborators)
Team Building: Two different Team Building activities have been developed. The barter puzzle and building a bridge. (1) Groups should complete a puzzle, but the pieces are mixed, and all groups have the pieces needed for the others groups to finish the activity. So, they have to strategize, assign roles and barter with other teams to get the pieces for their puzzle. (2) The groups are re-organized into bigger ones. Each group has the same material for building a bridge (dry noodles, lego, popsicles sticks, etc.). The goal is to construct two bridges as identical as possible. The groups can't see what the other team is doing. However, they are allowed to communicate verbally.					
Participants	**Duration**	**Space**	**Groups**	**Technical Orientation**	**Human Resources**
80	Four hours	Outside the university in entrepreneurs fair	4	The students will be engaged in different task that can be solved together. The students will be involved in large group Team Building as well as small group Team Building. Firstly, students are placed in set groups that are together for the entire Team Building. After, at the end of the activity all groups work together in a community challenge.	3 Lecturers and two external collaborators specialized in business events
Practical Case: Three different entrepreneurs present a real case of their companies. Students should solve the problems making choices like the real life and thinking about resources, communication and consequences. After, each group presents their solution. In the final part, there is a discussion regarding all proposed scenarios and decisions. Finally, the entrepreneurs explain their decision made and the results of performance related to them.					
Participants	**Duration**	**Space**	**Groups**	**Technical Orientation**	**Human Resources**
84	Two hours	The conventional classes	14	The Practical Cases were in five classrooms. Previously, lecturers work with entrepreneurs in creating some real problems or situations in their companies in a Practical Case according to case study method	3 entrepreneurs and 3 lecturers
Role Playing: There are cards with the description of a fictional business venture and there are some cards corresponding to investors. They are distributed among participants randomly. Each student has to perform come up with the role that they have. They have 60 min to prepare their speech. After this, they should present their business with the goal to achieve funds to their classmates. The ventures are presented almost exactly as they would be presented in a real-life situation—a three minute elevator pitch followed by an investor summary and financials.					
Participants	**Duration**	**Space**	**Groups**	**Technical Orientation**	**Human Resources**
85	Two hours	The conventional classes	First division into 5 big groups. In each group the participants are organized in pairs.	They work in pairs. Role Playing is developed in practical classes in which the number of students is less numerous	6 lecturers

In order to develop the different activities according to a standard and providing the lectures with support to implement and manage, a common guide was elaborated to make it easier and make the subsequent comparison possible.

Nevertheless, a fair distribution between students in each kind of activity was achieved, 80 students participated in team building, 80 in the Hackathon, 84 in Practical Cases, and 85 were involved in role playing. Additionally, three focus groups were carried out with the lecturers, an entrepreneur and students involved in order to evaluate which tools and resources for training entrepreneurial related competences entrepreneurship were better.

The participation was voluntary, but participants had to commit to the whole programme.

The sample consisted of 329 students, in order to maintain levels of statistical confidence (95%) and a statistically recommended margin of error (5%). Regarding the focus groups, a total of 24 participants took part in them (seven lecturers, an entrepreneur, and 16 students). When applying this technique, five persons who had not participated in the entrepreneurial training activities and one of the entrepreneurs involved in the case studies were included to improve the quality of the discussion. A focus group guideline was used to ensure it was implemented correctly.

3.3. Validity and Reliability

The literature reviewed already guaranteed the validity of the questionnaire, but in addition, the internal consistency of both questionnaires was validated as research instruments by applying Cronbach's alpha for all the factors forming each block, exceeding the reference values by 0.92 and 0.89, respectively. In addition, the confidence coefficient for the different dimensions on which the questionnaires are structured was checked and obtained results in the range of over 0.8 and 0.7, respectively. Entrepreneurial intention is the variable which depends on the three other dimensions in both. These three are independent and have a direct influence on the levels of entrepreneurship orientation among the students at Malaga University. Meanwhile, entrepreneurial intention and employability are analysed as a dependent variable of training/acquisition of entrepreneurial competences. In the same way, an analysis of data reliability and trustworthiness that was performed previously demonstrated that all measurement scales exceeded the 0.7 threshold for Cronbach's α in all blocks, both jointly and separately, therefore demonstrating a satisfactory internal validity.

3.4. Regression Analysis

Empirical testing in the field of entrepreneurship has been traditionally performed by means of quantitative techniques [9], this is the reason why qualitative analysis has a greater role in this study. Anyway, a regression analysis leads to focus groups. Regression analysis was chosen due to its versatility in identifying models of behaviour of the independent variables (predictors) and the criterion variable [76]. Previous literature has amply demonstrated dependence relation between entrepreneurial intentions with all other variables [40,81,82]. Therefore, new insights are pursued applying regression analysis linking entrepreneurial intention and improvement of employability with entrepreneurial competences. The technique was performed twice. In both applications, entrepreneurial competences remain as the independent/predictor variables (creativity, risk aversion, proactivity) and the dependent variable changing. Firstly, entrepreneurial intention related to entrepreneurial competences and, finally, the dependent variable is the improvement of employment perceived by students after their participation in the proposed activities. To increase the rigor of the application of the regression analysis, this is performed by using the default method, which consists of entering all the proposed variables into the model. The second phase involves the use of the backward regression method, which consists of introducing all the variables in the equation and then excluding sequentially those with smaller partial correlations. This procedure identifies large variances and the observations associated with small variances, determining which items have a minor impact [76]. All data analysis was performed using SPSS 20.

3.5. The Basis of Qualitative Analysis

Due to the descriptive and observational nature of the study, the qualitative analysis carries far more weight. The gathered data could support decision-making processes when designing entrepreneurship programmes and defining policies to improve student employability. Firstly, a general descriptive analysis is performed and the main correlations between key factors in this research are underlined. In the second part, data analysis considers the three focus groups. Their transcripts are the main source of information. The grounded theory approach [83,84] supports the structure and the procedure to understand which entrepreneurial training activities are more interesting and why. Atlas.ti is the tool used to systemize the data and provide the desirable insights. The feelings and opinions of the students and lecturers regarding the activities were identified and, finally, the focus was on their specific impact on developing entrepreneurial competences. The codification procedure consisted of identifying keywords or sentences. Only tags used more frequently are retained to provide a better understanding of the most significant questions and allow a more comprehensive comparison. The following step was to group the concepts, and, in any case, some re-coding of the tag was performed to achieve a wider vision. Figure 1 shows the data structure with aggregate dimensions and categories, while Figure 2 highlights the dynamic relationships between topics and dimensions.

4. Results and Analysis

4.1. Descriptive Analysis

Going into detail concerning with the multivariate regression analysis and the qualitative technique, we will carry out a descriptive analysis of the sample in order to present a general view of its make-up and show the main relationships between variables and their significance for the population.

As shown in Table 2, there are 46.5% men and 53.5% women. This percentage is in line with the gender balance distribution at Malaga University.

Table 2. Demographic factors.

		Frequency	**Percent**
Gender	Male	153	46.5
	Female	176	53.5
University Degree	Computer	19	5.7
	Engineering Industrial	18	5.5
	Engineering Sciences	35	10.6
	Tourism	72	21.8
	Business & Management	137	41.6
	Communication Sciences	34	10.3
	Social & Labour Sciences	3	0.9
	Law	11	3.3
Knowledge Area	Business & Management	137	42.0
	No-business & Management	192	58.0

The research was aimed at equally distributed students in the Business and Management and Non-Business and Management areas, precisely to overcome the gap in the literature, and mainly focusing on students participating in Business and Management faculties and the Economic and Business Sciences Faculties, totalling 42% vs. 58%.

All the degree courses selected contained material on business creation as part of the study programme. Nevertheless, one very important fact should be highlighted: Entrepreneurship is usually a compulsory subject in the last year and the sample contained students from different years. Consequently, there are students that have not taken that subject and, some students may even have taken it as an option or supplementary activity which fosters the entrepreneurial spirit organised by the university. In that case, a pre-existing inclination towards entrepreneurship is assumed [63]. In any event, the participation in this programme was open and the invitation was clearly identified as training entrepreneurial competences and not specifically to create businesses.

Table 3 shows the composition of the focus groups. The typological representativeness was sought with the presence of the different profiles and is correlated with the number of participants of each group in the whole project.

Table 3. Demographics factors of focus groups participants.

		Participants	Percent
Gender	Male	10	46.5
	Female	14	53.5
Knowledge Area	Business & Management	12	50.0
	No-business & Management	12	50.0
Kind of Activity	Hackathon	4	16.6
	Practical Case	6	25.0
	Role Playing	6	25.0
	Team Building	4	16.6
	Other Activities	4	16.6
Role	Students	16	66.0
	Lecturers	7	30.0
	Partners	1	4

4.2. *Quantitative Analysis*

In recent years, there has been an increase in entrepreneurial intention in university students, but it has not yet reached high levels [1]. However, entrepreneurial education programmes and other factors contribute to enhancing entrepreneurial intention and this question has been widely researched [11,85–87]. The aim of the study is to establish which tools are more efficient in improving entrepreneurial competences, understanding these as a key factor not only for business creation but also for employability. In this section, attention is paid to entrepreneurial competences and entrepreneurial intention as an indicator of being better prepared to face the labour market and professional development. Even so, it should be pointed out that quantitative analysis is not the core of this study. Firstly, some basic statistics are provided, and a regression analysis is found below.

Entrepreneurial intention before and after participating in training activities reveals a significant difference at the level of 0.3% (Table 4). Despite a general improvement in entrepreneurial intention, student's intention to start a business is moderate. However, it is worth noting that the item referring to the desire to start a business one day reached almost the maximum of 6 after participating in training activities. In this way, the item with fewer differences before and after participating is <I am ready to become an entrepreneur>. In both measurements, the score does not reach 4. That could mean that setting up one's own business is attractive but is long-term. This statement is reinforcing on the basis on the discussion held in focus groups, as well as in previous studies, highlighting Iqbal et al. [51], Fayolle et al. [11], and Nabi et al. [22]. Although it seems to have little relevance in quantitative terms, the qualitative results provide an interesting explanation of these values.

The research work focused on the positive effect between an entrepreneurial education program and entrepreneurial intentions are often found in the reviews of the literature [81]. In contrast, it is not usual to find evidence about how entrepreneurial competences should be learnt [12,88]. This is the reason that the focus is on the acquisition of entrepreneurial competences through educational programs. In Table 4, how this experiential learning contributes to gain these kinds of skills is shown. All the values are notably increased after the participation in the training activities.

Table 4. Average entrepreneurial intention and entrepreneurial competences before and after participating in training activities.

	Before Training Activities	After Training Activities
Entrepreneurial Intention	4.4	4.7
Creativity	4.9	5.4
Risks Taking	3.7	5.2
Proactivity	4.9	5.1
Entrepreneurship Image	3.1	5.2
Entrepreneurial Competences (Sum of the Averages)	4.2	5.2

Although good progress has already been made in this field, there is no unanimous answer to the discussion about which pedagogical methods and learning tools are more efficient in higher education from the point of view of entrepreneurship [11,87]. An additional effort should, therefore, be made in this research line [40]. This study shows a significant correlation between entrepreneurial intention and training activities at the level of 0.05. However, the main point is to find out which tools can better improve entrepreneurial competences. Table 5 shows the impact of each one on entrepreneurial intention. All levels are quite similar but including the qualitative vision in the later analysis again allows the contrast of impressions and feelings regarding traditional learning methods and practical approaches to be appreciated.

Table 5. Entrepreneurial intention classified by type of training activity.

Training Activity	Entrepreneurial Intention (EI)
Hackathon	4.8
Team Building	4.9
Practical Case	5
Role Playing	4.2

To provide a holistic vision, a regression analysis was performed. The analysis of data aimed to confirm the working hypothesis that asserts the existence of relationships between each entrepreneurial competence considered in this study (risk aversion, creativity, and proactivity) and the dependent variables tested (entrepreneurial intention and employment) applying the multivariate regression technique for each model of relationships. This research work focuses on three parameters to validate the aforementioned hypotheses: the fit of the model, the ANOVA table, and the Durbin-Watson test.

Previously, the correlation matrix for entrepreneurial intention and employability is positive, although changes were detected in the weight of the predictors in each model. Consequently, hypothesis 1.1 and 1.2 are tested.

Hypothesis 2 and 3, relate the three entrepreneurial competences with entrepreneurial intention and employability, shows the dependence separately. Consequently, both are positively confirmed. The coefficient of multiple correlations and its square indicate that the proportion of the variance of dependent variables explains 78% of the model in the case of entrepreneurial intention and 77% in the case of the improvement of employability (Table 6). The explained variance is reduced if we take the value of the adjusted R Square to 53% and 52% respectively. The sample size allows us to consider as statistically significant lower levels of R2 in samples ranging from up to 350 with a number of independent variables of 10 [76]. Consequently, for our case study, the explanatory capacity of the model is accepted.

Table 6. Model summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
EI	0.784a	0.534	0.512	1.498	2.110
Employability	0.778a	0.529	0.507	1.401	2.002

a. Predictors: (Constant), Psp, Cnw, ARsi, ARr, ARer, Ci, Pow, Pi, Co. b. Dependent variable: Model 1. Entrepeneurial Intention/Model 2. Employability.

The regression model has been applied by following two methods: the default method, in which all variables are entered into the equation, and the backward elimination method, in which the variables are entered into the equation and then the variables that contribute less to the model are eliminated sequentially to correct the lower partial correlations and thus offer a more appropriate value of adjusted R2. The ANOVA table (Table 7) confirms that the result of the analysis of variance of the model is significant because the value is 0.00. This coefficient allows discarding the null hypothesis and demonstrates a linear relationship between the dependent variables and the independent variables that is not due to a chance.

Table 7. ANOVA.

Model		Sum of Squares	Df	Mean Square	F	Sig.
EI	Regression	218.573	9	24.286	10.828	0.000b
	Residual	715.511	319	2.243		
	Total	934.084	328			
Employability	Regression	218.573	9	24.286	10.828	0.000b
	Residual	715.511	319	2.243		
	Total	934.084	328			

The last step was the Durbin Watson test. It confirms that the residues are serially correlated. The suggested values to state the residues are independent should be in the range of 1.5 and 2.5 and these values are fulfilled for both models of regression (Table 6).

For the purposes of this particular study, the most important finding is the empirical demonstration that the training of entrepreneurial competences has an overall positive impact on entrepreneurial intention and on employability. Basis on linear regression we can measure significant differences in each of the two dimensions between university students after their participation in the training activities. Creativity, risk aversion, and proactivity impact positively on entrepreneurial intention and employability as well. Consequently, the three proposed hypotheses are tested.

4.3. Qualitative Analysis

Three focus groups were conducted in order to have a complete view of the topic. Sixteen students and eight lecturers were recruited to participate in focus groups. As explained in detail above, five persons who had not participated in the training competences activities are included in the groups. Moreover, one entrepreneur specializing in design dynamics was included in the focus group with university lecturers and an effort was made to ensure that each group had participants from the Business and Management area and also Non-Business and Management, along with including students in their final and first years and lecturers linked to the business creation subject and who are not linked. Finally, the gender distribution is similar in each group. Table 8 shows the profiles and composition of focus groups.

Table 8. Participants in focus groups.

Focus Group 1—Students A
1. Participant student in business & management degree Hackathon (F) 2. Participant student in business & management degree Teambuilding(M) 3. Participant student in Practical Case study with business & management degree entrepreneur partner (F) 4. Participant student in business & management degree ring (M) 5. Participant student in non-business & management degree Hackathon (F) 6. Participant student in non-business & management degree Role playing (M) 7. Non-participant student in first year of business & management degree (F) 8. Non-participant student in final year of non-business & management degree (F)
Focus Group 2—Students B
1. Participant student in non-business & management degree Hackathon (M) 2. Participant student in non-business & management degree Team Building (F) 3. Participant student in Practical Case with entrepreneur partner of non-business & management degree (M) 4. Participant student in business & management degree Role Playing (F) 5 Participant student in business & management degree Team Building (M) 6 Participant student in Practical Case with entrepreneur partner of business & management degree (F) 7. Non-participant student degree in first year of non-business & management degree (M) 8. Non-participant student in final year of business & management degree (M)
Focus Group 3—Lecturers
1. Lecturer involved in Hackathon and in Role Playing activity (F) 2. Lecturer involved in Team Building and in Practical Case with entrepreneur partner (F) 3. Lecturer responsible for business creation subject but non-participant in the pilot training activities (M) 4. Entrepreneur partner in Practical Case training activity (M) 5. Lecturer involved in Hackathon and Practical Case (M) 6. Lecturer involved in Teambuilding and Role Playing activities (F) 7. Lecturer responsible for business creation subject and participant in all training activities. (F) 8. Non-participant lecturer in the pilot training activities, with no relationship with business creation programmes but with some involvement in work experience programmes (M)

The content analysis of the transcript resulted in 4 themes: entrepreneurship, employability, teaching methods, and competences (based on main objectives and core topics for the research), which were used to set the categories and the codes, based on the prompted topics within the groups and supported in the literature review. Deductive and inductive methods for creating codes have thus been combined [89]. Table 9 shows the different conceptual levels.

Table 9. Key themes, categories and codes.

Themes	Categories	Codes
Entrepreneurship	Entrepreneurial Education Entrepreneurship as transversal Competence Entrepreneurs	Entrepreneurs image Global vision of entrepreneurship
Employability	Labour market demand Business creation Paid-employment	Competences & Employability
Teaching methods	Traditional methods Innovative methods Challenges in Higher Education	Traditional teaching Practical and innovative teaching methods Positive aspects of OI university image
Competences	Training competences Value of the competences Effects of competences	Knowledge & Competences Challenges in training competences Receptivity of training competences

The key themes were discussed extensively and the categories and particularly the codes therefore summarize the content from the discussions held in the groups. This result derives from a clean-up exercise to correct and delete duplication or reduce similar concepts to a single code.

Figure 1 shows the occurrence frequency of each code in the three focus groups and, consequently, the relevance of each topic.

Codes Wood
Challenges training competences {36-1}
Competences & Employability {34-1}
Entrepreneur image {8-1}
Global Vision Entrepreneurship {18-1}
Knowledge & Competences {15-1}
Receptivity to train competences {17-1}
Skepticism {8-1}
Strengths training competences {27-1}
Teaching of entrepreneurship {6-1}
University Image {8-2}

Figure 1. Codes Wood. Source: In-house elaboration with support of Atlas.ti.

Finally, a network figure was used to show the relationship between concepts, to connect them, simplify the discussed ideas and to supply an overall view (Figure 2). This phase is called relational and is based on frequencies, relationships found in categories and codes.

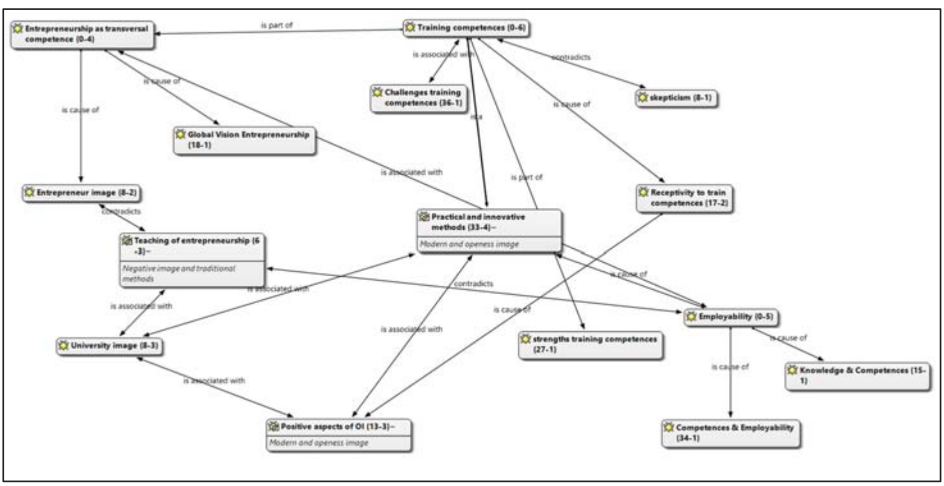

Figure 2. Codes network entrepreneurial competences Training. Source: In-house elaboration with support of Atlas.ti.

Looking at the details of tools and their measurements more effectively (Table 10), it should be stated clearly that the practical case with an entrepreneur gets the best overall results (5.5), followed by the hackathon (5.3), the team building (5), and role playing (5,5) is placed lowest in the ranking (4.8). These values agree with the comments and remarks made by students in the focus groups. Nevertheless, there is a contribution of some training activities to additional extra competences. For example, the hackathon is the training activity that allows the participants to better developed creativity and risk tasking is trained more with the practical case with an entrepreneur. Meanwhile, the role playing is shown as the best tool for improving empathy and negotiation skills and team building is positively valued for acquiring communication skills.

Table 10. Entrepreneurial intention and competences classified by type of training activity.

	Entrepreneurial Competences						
	EI	Creativity	Risks Tasking	Proactivity	Entrepreneur Image	∑ Entrepreneurial Competences	Additional Outstanding Competence Mentioned in Focus Groups
Hackathon	4.8	6	5.3	4.4	5.8	5.3	Teamwork, communication skills
Teambuilding	4.9	5.7	5.2	5	4	5	Teamwork, negotiation skills
Practical Case with an entrepreneur	5	5	5.6	5.2	6.3	5.5	Problem-solving skills, self-management
Role Playing	4.2	4.9	4.7	5.3	4.5	4.8	Communication skills, employability

5. Conclusions and Discussion

The most interesting conclusion has arisen out of the qualitative analysis. However, the multivariate analysis provides an in positively sight into the positive effect of training entrepreneurial competences on entrepreneurial intention and employability. It will be the focus that should be at the forefront of future research. Centring on quantitative analysis, this research work demonstrates the relationship between acquisition of entrepreneurial competences and entrepreneurial intention. However, the main contribution is shown as the training these kinds of skills can contribute to the employability. Although in this study employability is a students' personal perception and a definitive confirmation supported with companies should be developed in the future. The model of relations of dependency proposed in hypothesis 3 is tested. In previous research works, as Liñán and Fayolle [81] the testing of the positive effects between competences and entrepreneurial intention is widely examined but the introduction of employability is less common [64,90]. Moreover, seeking the capacity of different training activities to influence both factors is the main contribution of this research work.

The three focus groups explain briefly the potential between training competences and employability in line with Rae [16], Sánchez [10] and O'Leary [13]. Moreover, there is a consensus regarding innovative and practical methods having positive effects on learning, on motivation and on the predisposition of students [4,11,87]. The results allow us to obtain a positive response to the first research question raised. The general perception among major education stakeholders is that competences are useful for facing the labour market better and, specifically, entrepreneurial competences are more greatly appreciated by companies. So, they are not only a key for self-employment. Curiously, both lecturers and students stressed they would like to participate in these kinds of practices but emphasized how hard it was to achieve, usually due to a lack of tools, or as the result of the relative rigidity of education programmes in higher education. This statement reinforces the positive relationship between participating in entrepreneurial education programmes and increasing entrepreneurial intention [45]. Furthermore, this study provides keys to show which and how learning methods and practices are more effective. In this way, Neergaard et al. [19] also coincide with the reflection that higher education often focuses on knowledge acquisition, rather than the deeply experiential approaches and searching for the collaboration of students. Lecturers also assume the need to be trained, advised, equipped, and supported for this challenge, and curricula need to be modernized [63]. It should also be noted that the participants agree that the right balance between knowledge and competences should be established in order to achieve quality higher education and to ensure a better match between academic requests and labour market demands. This is in line with Wells [91] and Cai [66]. Regarding previous literature, this study delves deeper into a didactical level of training activities for training entrepreneurial competences. It should be emphasized that this study completes and is somewhat similar to the results of Morris et al. [62] Following the directions of Fayolle [21] audience, knowledge and content, objectives, methods, and assessment are described and evaluated to provide a wide and comparative vision of each learning tool. In addition to contributing to the field of entrepreneurial education based on competences, the details of how it is done in practice are also given. Consequently, this initiative may show enough to allow other universities and researchers to carry out these activities and continue in this line.

There is a unanimous consensus about how competences help them as lecturers and as students to improve to face not only their professional challenges but also their daily lives as well. In this regard, the highlighted gap [45,46] receives more attention and more evidence is provided. Certain participants raised some doubts, but they specifically highlight the direct impact on their skills when there are only specific training competences activities. In general, all participants were receptive to these experiences and they felt that training competences had a positive effect on them.

Focusing on entrepreneurship, the change of perspective regarding how being an entrepreneur should be emphasized. It seems that, generally speaking, students link entrepreneurship to business creation, and they had not previously thought about it as an attitude to life. In this line of thought, the research work by Lans et al. [12] reinforces the statement that entrepreneurial competences have a positive implication beyond having a business. Additionally, training activities have generated improvements in the traditional entrepreneurial view. It is particularly noticeable in those who have participated in solving a practical case with an entrepreneur. The downside to current business creation teaching methods is that it seems boring or scarcely credible. Elaborating a business plan is not seen by most students as a motivating activity to awaken their entrepreneurial spirit, rather the contrary. In any event, this question is consistent with the opinions expressed in favour of the innovative and practical learning methods coinciding with the considerations of Dacre Pool and Seewell [64]. University image is closely linked to the previous topics. Participants affirm that innovative teaching methods and taking the most valuable labour market competences into account could bring considerable improvements in this regard. Even today, university is considered an educational institution with a rigid structure, quite permeable to the environment and the student requests. However, the efforts towards openness and experiences to introduce innovative learning methods are a chance to modernise and positively change its image, according to the opinions given. Additionally, the entrepreneurial view should be highlighted as entrepreneurs reinforce the idea regarding the change of focus needed in the relationship between university and business sector. They appreciate that the university is seeking to improve graduate employability, adapting their competences to labour market requirements. In a certain way, adapting curricula to achieve a positive effect on the competences for entrepreneurship agrees with Arranz et al. [63].

To sum up, the most influential training activities on students' skills have the following factors in common: (1) they are based upon real problems or situations and their solutions imply relying on their capabilities and their ability to find real solutions instead of applying answers based on theoretical knowledge. (2) Teamwork enriches the learning experience and encourages and develops the participants' competences. (3) The participation of an entrepreneur in the training activities is very appreciated and adds an incentive. Overall, all these items have already been noted by Fayolle [21] who after a thorough revision of literature highlights the importance of active, experiential, learning by doing real-world pedagogies. This principle ensures that training of competences is successful. In this way, this study answers the second research question and deepens the nature of the interventions: methods, content, resources, organisation of the groups, time and space.

Last but not least, OI was appreciated, even the lecturers considered it a chance to engage the students and improve the level of participation in their lessons. This statement responds positively to the third research question raised. Moreover, it has a beneficial impact on the modernization of university image and receptiveness of higher education. In Sharples et al. [27], considerations in this line are made.

The role of competences in the so-called European Higher Education Area (EHEA) derived from Bologna Process' decade anniversary seems not to be under discussion, even though several challenges remain unresolved regarding how and which pedagogical instruments develop employability efficiently [16,91]. This study is innovative as its aim is to test which training tools have a greater influence on entrepreneurial competences. Moreover, how this set of skills is perceived as valuable for the labour market. The feeling of students and lecturers and personal impressions regarding which educational and didactical methods work are necessary. This approach is not usual [22] and its introduction is the most highlighted contribution.

The findings may suggest that student involvement in discussion and evaluation of tools to train entrepreneurial competences may enhance motivation and learning outcomes. This requirement is made in previous literature as well [4,6,10,64]. As for lecturers, they point out that OI helps them to achieve a positive attitude towards learning in lessons and they acknowledge they are more motivated thanks to the better performance seen in student competences. Consequently, the main finding is that students' involvement in the decision-making process regarding tools to train entrepreneurial competences through the OI approach has a positive and direct effect on student motivation and their learning and professional outcomes. In this way, this research work agrees with Fayolle [21] (p. 700), who highlights that entrepreneurial learning and entrepreneurial outcomes should adequately meet the social and economic needs of all the stakeholders involved and to achieve it, the creation of a community sharing the same values and objectives is key.

The university can take advantage of providing a platform where entrepreneurs can connect with lecturers and students in order to test which knowledge and competences are more in demand by companies. This could support the design and implementation of innovative methods. The co-creation channels reinforce the social commitment in higher education, and it would be to the benefit of all parties (university, students and productive sector). Working with this philosophy, the essential elements of a practical model which optimizes the value of the collaborative innovation between the educational institutions (or agents) and the interest groups can be established in the same way as Cai [66]. To sum up, OI practices in the educational environment allow an accurate adjustment of objectives and results due to the active role of stakeholders in their strategy.

Therefore, some considerations highlighting the contribution are made. Given the length of time, entrepreneurial learning cannot be considered a new or even emerging field of study, but rather one that has been established and has been organized in different research areas and topics [64]. The TPB model [47] is widely used for measuring entrepreneurial intention but competences and the influence of different training activities are added in this study [10]. Consequently, this research work reveals how entrepreneurial intention and self-perception about competence profile can change depending on the methodological, pedagogical approaches used in the learning process. Moreover, the collaborative model, specifically, OI practices clearly show better performance and engagement in the educational environment. This research paper contributes to providing evidence that the learning perspective and widening the interpretative framework of entrepreneurial learning to foster entrepreneurial development in a transversal competence are not only linked to business setup, but also employability is positively improved.

5.1. Limitations and Future Research

Despite new insights provided, the research work is not free of limitations. This study is exploratory, although it provides clues about the design of education program focus on entrepreneurial competences, a deeper analysis is needed. The results reveal a positive effect on employability from the point of view of students, lecturers and entrepreneurs but a longitudinal study, the inclusion of more universities will provide vital support for the validity of this research work. The study has chosen only one university, although the case shows that training entrepreneurial competences achieves to improvement in their professional profile, it is necessary a further examination to provide a complete vision of the phenomenon. Likewise, additional data about the effects on the entrepreneurial intention from training activities should be carried out in order to confirm the reliability and validity of this first approach. Additionally, employability should be studied in the future not only supported in the students' personal evaluation and this vision should be completed with the perception of companies that recruit graduates.

Despite the deepening development of entrepreneurship, there are still certain under-researched areas particularly relating entrepreneurial competences to employability. Future research may place more emphasis on empirical evidence that will show how the different training activities improve and reinforce key competences in a successful professional development with one's own business or working for whichever company. Moreover, it could also be interesting to explore how the university community (students and lecturers) reach a wider understanding of entrepreneurship, thus overcoming stereotypes about entrepreneurship and about traditional learning methods based on intensive knowledge and less on practical and valuable competences in the labour market. This requires more qualitative, phenomenon-driven research, which is especially effective in addressing how higher education can ensure better current requirements for their graduates and companies as well.

Additionally, it would be of interest to carry out a comparative analysis at an international level to establish how, beyond cultural factors, the approach of each university in this field can raise the levels of entrepreneurship in the university community and determine the differences in student entrepreneurial intention and in the improvement of each entrepreneurial competence according to the type of activity. For this purpose, additional multivariate analysis can provide a good basis for progress in this area and making sense of this first exploratory study. Further research based on mixed-methods can hopefully allow for generalizing this result.

5.2. Practical Implications

The results encourage universities to implement initiatives aimed to give entrepreneurial skills to graduates to make easier for them to get into the job market. Some of the issues mentioned above could be a support to design educational programme in accordance with labour market requirements. OI practices allow universities valuable training before making it a standard and compulsory practice in educational environments. The assumption behind this framework means that a global vision of entrepreneurship should be considered to design effective learning processes that allow university students to gain the knowledge and skills to be successful if they create an enterprise or enter the labour market. Additionally, the university develops and strengthens their social commitment as well as increasing their stakeholder's engagement in strategic renewal processes. A participatory and open model involving lecturers, students, and entrepreneurs is needed to achieve the expected results. Thus, the university is firmly committed to increasing the availability of training resources and tools over the coming years for these kinds of proposals with guarantees and the support necessary for the academic staff.

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The Impact of Higher Education on Entrepreneurship and the Innovation Ecosystem: A Case Study in Mexico

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Abstract: Entrepreneurship is recognized as an engine for the economy. However, Latin America must promote higher opportunities for the creation of new businesses, especially for technology-based ventures. In this sense, the Center for Global Innovation and Entrepreneurship (CGIE) of the University of Texas at Austin offers a Master of Science in Technology Commercialization (MCCT) that prepares students with methodologies to promote the creation of new businesses in Mexico. This study aims to know the contribution of training to the creation of new companies, and its role in the innovation and the technology transfer processes, from the viewpoint of the participants. This research presents a case study that analyzes the impact of the MCCT through the analysis of the data of a survey answered by 109 former students of this center. Findings show that the methodologies developed by the MCCT allow the creation of technology-based enterprises and entrepreneurial skills in students. This study presents good practices that can be emulated by other countries in the region, as well as recognizing the great value the role of higher education in creating synergies between actors of the innovation ecosystem that strengthen social and economic growth.

Keywords: business creation; technology transfer; innovation; innovation ecosystem; entrepreneurship education; science and technology; sustainability; higher education; educational innovation; Mexico

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1. Introduction

In the new knowledge economy, innovation plays a fundamental role in the socio–economic development of regions [1]. This growth is associated with the dynamism of companies, especially in the roles played by small and medium businesses [2]. In this context, entrepreneurship is a factor that favors the search for opportunities and innovation with a positive impact on the countries' wealth [3]. Additionally, a sufficient mixture of specific conditions of the entrepreneur, a favorable business climate, and the needed infrastructure is required, as are legal and political conditions that encourage people to create new businesses, especially in the case of Latin America, where this performance has been weak [4].

To achieve this growth, the interaction of diverse actors of the innovation ecosystem is necessary; elements such as access to information, training of human capital through universities and research centers, access to funds, and business opportunities related to the market, customers, and suppliers affect the creation of new ventures [5]. In this interaction, institutions such as universities include educational programs for entrepreneurship to develop creative and innovative talent, which provides opportunities to generate knowledge and networks [6].

As mentioned earlier, human capital formation is a fundamental element of economic growth and innovation [7]. Therefore, previous studies have determined how training projects in universities help to increase the culture of innovation through the promotion of entrepreneurship. One of the studies conducted by Diamantini and Tommasone [8] in Brazil analyzes, through a case study, the contribution of the Master's degree in Innovation Management for Local Development offered by the Fluminense University of Rio de Janeiro and taught by experts from the University of Milano-Bicocca of Italy.

This Master's program provides students with tools to build new businesses and to transform their environments, especially seeking to analyze the main elements of innovation and technology transfer, which promote entrepreneurship and the relationship with other actors, such as incubators, small and medium enterprises, and technology parks. The research concluded that interaction among the different actors is needed to achieve economic growth, although it is not possible to define correct policies without knowing the ideas of those who are experiencing the situation.

Another study was made by the KICKSTART group, integrated by nine institutions of higher education from Latin America and Europe. The research objective was to seek new practices that generate innovation in the countries of the Latin American region [9,10]. In this study, strategies were used to improve the quality of the teaching–learning process to seek the development of professionals with an innovative approach. For instance, in research conducted in Tecnológico de Monterrey, Mexico, leadership was determined as a fundamental element that must exist in the professionals responsible for developing innovative strategies. Furthermore, this leadership should seek interaction with the tools that allow the transfer of innovative products and processes to generate projects that solve problems in their environment. However, not all teachers knew how to implement these approaches [11].

Therefore, the university needs to be involved in the innovative and entrepreneurial talent training processes, and one of its functions is to prepare citizens to join the productive processes and the generation of wealth [12]. Entrepreneurship education should support the student to learn by doing, incorporating mentors, networking, and increasing the interest of creating a new business [13,14]. However, authors consider that there are still programs that are closer to theory than to practice [15–18]. Thus, understanding the best practices in developing different skills in individuals to meet the new requirements becomes an indispensable factor for improving competitiveness [19].

In this context, the IC^2 Institute of The University of Texas at Austin developed the Master of Science in Technology Commercialization (MSTC) in 1997 and began a similar program (MCCT) in 2009 in the city of Monterrey, Mexico, managed by the Center for Global Innovation and Entrepreneurship (CGIE). This center has graduated 250 students who have developed 54 technology-based entrepreneurship projects in Mexico. The cohorts and team membership were designed to evenly mix as managers and directors in national and multinational companies, professors and researchers in universities, and entrepreneurs. Also, a number of former students have started new ventures after taking the program.

Analyzed literature indicates that there is a gap between what universities teach and what students can apply in their lives [20,21]. Some programs are more theoretical than practical, which does not allow students to prepare for the needs of today's society [20]. It is also necessary to know the effects of this training on the development of the regions, but few studies have analyzed them. It is especially relevant for Latin America, where the dynamism of innovation has been limited [4,22]. Hence, this study aims to know the impact on professional development and venture creation from the viewpoint of those who received training in innovation. Also, it seeks to answer the following question: How can higher education institutions have an impact on the development of entrepreneurship and innovation? By understanding the vision of people involved, it is possible to know the contribution that this type of training has in the creation of new companies and in the processes of innovation that can generate a transformation in the social, economic, and political problems of the region.

This article is structured as follows. First, it presents the literature review related to training for innovation and technology transfer. Second, it describes the context in which it was developed. Third, research methods explain how the research was conducted. The following section presents the results and the analysis of the data obtained with the instrument. Finally, it develops the discussion and conclusions of the research.

2. Literature Review

In recent years, different studies related to the development of innovation and technology transfer have appeared, and they consider the following elements relevant for improving the economy and promoting innovation and entrepreneurship.

2.1. Training for Innovation

According to the Oslo Manual, innovation is a new or improved product or process, different from the original and available to users [23]. These changes promote economic and scientific progress through research and the development of new strategies [15]. Additionally, innovation is associated with the formation of human capital that has the necessary skills, because professionals who are part of the innovation processes of the public and private sectors are required to be competitive in the products and services they offer [20]. Therefore, to train future innovators, it is crucial to establish strategies that encourage creativity and promote the required skills to participate in innovation processes.

In this regard, the training processes should bring the student closer to what they will experience in real life, through a pedagogy of innovation where elements known as meta-innovations converge [21]. These elements are, according to Keinänen and Kairisto–Mertanen [20], active teaching–learning methodologies, multidisciplinary learning environments, integration of working life, research and development (R and D), flexible curriculums, entrepreneurship, and internationalization. The path of the training of students to participate in innovation is in Figure 1.

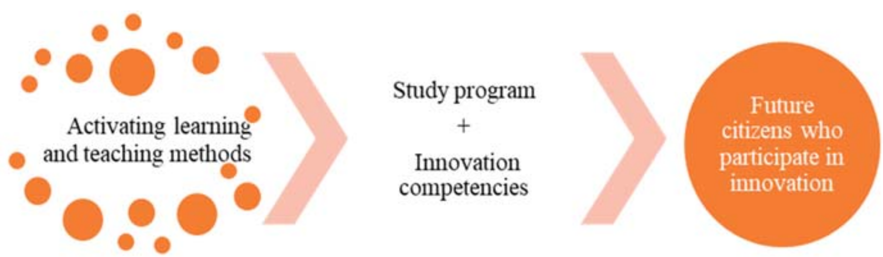

Figure 1. Path of the training of students to participate in innovation, according to Keinänen and Kairisto–Mertanen [20].

The meta-innovation processes are active learning methodologies that allow students to build knowledge and meaning to the situations they experience in the educational process, and the orientation of working life that enables learning around real-life situations working on projects with other colleagues. This participation of other people must be multidisciplinary, so that students can share competencies and interact with each other. The flexibility of the curriculum allows following different trajectories according to the needs and interests of the students. It should also give the possibility to promote entrepreneurship, which implies risk management and the search for opportunities. Finally, internationalization will make it easier to develop competencies to participate in an increasingly globalized world [24].

Entrepreneurship is a relevant factor for the economic development of a region [25]. Also, the entrepreneur's role is looking for solutions to problems and bringing these answers to the market. Schumpeter [26] states that the entrepreneur creates new ideas that lead to changing the market with new ways of doing things. This type of innovation is known as a technology push, where the entrepreneur proposes the change and can introduce a new product or a new production method, open a new market, or make a new industry organization. On the other hand, Kirzner [27] promotes market pull, where the needs of the market lead the entrepreneur to propose a solution [28].

For Rypestøl [25], these classifications are useful to distinguish entrepreneurs and companies, but they do not allow for determining the impact that new ventures have on the development of a region. Besides this, it is necessary to consider the effects of entrepreneur training, as well as the conditions that favor interaction with other actors such as universities, accelerators, incubators, and research centers to generate the expected development and economic growth.

2.2. Technology Transfer

Latin America has had an increase in entrepreneurship in recent years. However, despite its potential, this region has not achieved the dynamism of innovation that other areas have, in addition to the rise of informal enterprises [22]. As reported by Amorós et al. [4], the little development of innovative companies on this region is caused by three main reasons: 1) a lack of connection of research and development with the creation of new companies, which does not allow the transfer of technology; 2) little application of technology in business models; and 3) lack of public policies that support technology-based companies.

It is crucial to promote entrepreneurship training and innovation to reduce these causes. Furthermore, it is essential that the transfer of knowledge takes place in universities and that research and the search for solutions to society's problems make it easier to commercialize these innovations [29]. Recent studies found a gap between education for entrepreneurship and technology transfer because, in the university, commercialization of technology occurs in controlled environments and its development outside of this context is scarce [30].

An environment to form successful entrepreneurs, in which they can innovate and develop their businesses, is required. The existence of an innovation ecosystem is essential, where the conditions facilitate and give support to the entrepreneur, with an agenda that promotes the processes of entrepreneurship. The degree of success will depend on the development of a virtuous circle to improve economic development, as well as the conditions for innovation, entrepreneurship, public policies for competitiveness, and the growth of a knowledge-based economy [31].

Lackéus and Williams [32] notice that the programs that look for the creation of companies have potential to form interdisciplinary groups of students, offering a diversity of problems to solve, and a portfolio presented by the teachers. These characteristics challenge academic institutions because they require coordination among different disciplines, integration of other actors, and responsibility for the intellectual property of the ideas generated in the programs.

This study analyzes theoretical aspects, based on the opinions of the interviewees and the reality of the context in which they work. Good practices can be known to reduce the identified gap by presenting activities that are being used by higher education centers, such as CGIE, as well as showing the impact on the development of students' innovation and entrepreneurship skills, making these experiences visible in order to continue exploring their effects. The next section presents this context and contains ways in which the research gap is addressed.

3. Context

CGIE is in Nuevo León, Mexico, a state traditionally characterized by industrialization. In 2004, Nuevo León started a process to attract and create technology-based companies. These programs were developed by the local state government to constitute the Monterrey International City of Knowledge (MICK) in 2008, the main propositions of this model being [1]:

- Form a culture of knowledge through a long-term vision, with goals to be met by 2025.
- Form a legal framework to guarantee the continuity of the program promoted by the Institute of Innovation and Technology Transfer (I2T2).

- Provide the necessary resources through funds for innovation, as well as funds for seed capital to help form new companies.

The project sought to attract research centers and technology companies to achieve the vision of the model, for which the Research and Technological Innovation Park (PIIT) was created. The purposes of the PIIT were to integrate research and innovation to encourage a culture of innovation in the inhabitants, and increase the attraction of capital and the formation of high-tech industries [33]. CGIE is in this park as part of the effort to create ties among academia, industry, and government. The objective of the center is to develop educational programs that promote the commercialization of science and technology, taking advantage of the experience of the IC^2 Institute to improve the economic development of the region [34].

Currently, the long-term model proposed by the Government of Nuevo León continues, with the extension of the Strategic Program in Science, Technology, and Innovation [35]. This program defines policies and actions to ensure that science and technology contribute to economic and social development. According to this report, despite current efforts, science and technology must be further developed in the state. This program is aligned with the National Development Plan, which seeks to achieve the national goals of quality education and prosperous Mexico, along with the Sustainable Development Goals concerning people and prosperity [35].

For this program, the State of Nuevo León has launched the Nuevo León 4.0 initiative, which seeks to position the city of Monterrey as "Monterrey, International City of Advanced Manufacturing and the Knowledge Economy." Therefore, the objectives defined by the PECTI 2016–2021 to promote scientific, technological, and innovation development are related to the work of CGIE. These goals are to strengthen the capacity to create and attract technology-based companies, develop leadership training programs in entrepreneurship based on innovation, promote scaling and marketing programs for new products and services, develop a network of experts to advise innovators, support the training of talent, and create international collaboration networks, among others.

The following is a description of the CGIE program and the elements that favor the achievement of the mentioned objectives. Subsequently, the answers stated by the former students are analyzed through the impact of the master's degree on supporting the development of science, technology, sustainability, and innovation as generators to achieve economic and social growth.

Master of Science in Technology Commercialization (MCCT)

CGIE imparts the MCCT in the city of Apodaca, Nuevo León, Mexico. It aims to develop skills in students that allow them to transform a technology-based product or service into a business [36]. With this program, the participant, whether an entrepreneur, researcher, academic, or technology manager, is expected to understand the process of technology transfer and value creation and develop a new business.

This master's degree program promotes students to accomplish, from the first day of classes, a real project of technology transfer following the concept of *Think and Do*. Students select a project from a technology portfolio and evaluate its marketing potential through the methodologies of the master's degree. The student team then develops a business model and commercialization roadmap to propose a viable business [36].

The program runs for a year and comprises 12 subjects, of which two are taught every two months, with a duration of 32 hours each, and a final project under the model of a Capstone Project. Also, an initial session is used to make the groups that develop the projects. During the program, students must generate a technology commercialization project with a practical approach. The subjects that form the study program are [37]:

- *Converting technology to wealth:* using the Quicklook methodology to evaluate the potential of the technology to be commercialized and defining a contextual framework to bring the technology to a market.

- *Marketing technological innovations:* designing a marketing plan for the launch of a product or service based on technology using the principles of persuasion.
- *Legal aspects of the marketing process:* addressing aspects related to intellectual property in the development and commercialization of technology-based companies.
- *Risks analysis:* applying techniques to identify risks and make decisions.
- *Financing new ventures:* reviewing the construction and interpretation of financial statements, investment, and capital funds and the preparation of financial projections.
- *Managing product development and production:* the course seeks to understand customers' needs to generate a prototype.
- *Technology management and transfer:* understanding the models of technology transfer in national and global environments to implement them in technology adoption processes.
- *Strategic analysis of technology commercialization:* evaluating the potential of the industry to apply the value proposition and assessing the company's capabilities to develop a successful strategy.
- *The art and science of entrepreneurship driven by the market:* consisting of entrepreneurship planning and market evaluation to establish a viable business concept.
- *Internationalization of technology*: understanding the global processes of technology transfer to perform business processes and strategic partnerships.
- *Creative and innovative management*: communicating of ideas for commercialization, developing leadership skills and generating creative and innovative ideas.
- *Technology enterprise design and implementation*: including the necessary elements to launch a new company and identify the success factors and the risks associated with the creation of a technology startup.

CGIE participates in initiatives such as *Cleantech Challenge Mexico,* which is an economic development program to promote the generation and implementation of clean technology in Mexico, which trains researchers to explore the market potential of the technologies they develop [38]. And *NoBI* (Bi-National Innovation Nodes), with initiatives as sustainable building materials, biodegradable products, solar cells, and products for the detection of diseases such as diabetes, among others [39].CGIE´s function is to support the organizers to achieve the integration of programs to support entrepreneurship for the generation, commercialization, and financing of technological solutions to environmental problems [38].

Besides this, the projects prepared by CGIE former students have been recognized as factors of change for Mexico, promoting social and economic development. For instance, some projects are for:

- *Developing future entrepreneurs:* Yeii (Young Entrepreneurship and Innovation International) is a business created by two alumni that seeks to form innovation and entrepreneurship among primary, middle, and high school students. The initiatives proposed by the young students attempt to solve social problems, develop their entrepreneurship and innovation skills, and participate in an authentic process of entrepreneurship [40].
- *Developing a regional innovation ecosystem:* Tomato Valley is an initiative carried out by two former students in western Mexico. The objective of this project is to promote technology transfer in the region's businesses which has favored the agroindustry sector that characterizes the area and the promotion of social entrepreneurship [41].
- *Influencing public policy:* the participation of directors and researchers of centers of the National Council for Science and Technology (CONACYT) allowed changes in public policy to adopt the practices proposed by the MCCT [42].

Currently, the concept of sustainability has expanded, and educational institutions have an interest in developing sustainable behaviors [43]. In this sense, the projects developed by alumni have allowed users to propose solutions to social problems while favoring the innovation promoted by these initiatives at the same time.

4. Research Methods

The present research follows a qualitative case study methodology [44] that seeks to describe the impact of the MCCT taught by the CGIE in Mexico on the development of entrepreneurship, innovation, and technology transfer by the former students of the program. The case was selected to highlight the importance of this type of training for the development of competencies that promote competitiveness and innovation, especially in Latin American countries [8]. This methodology was selected because a case study allows enquiring into a particular case with the intent to understand a specific issue [45]. Also, the problem is best understood through an in-depth analysis of the data collected by the instrument to generate categories and subcategories of analysis based on the case study [46].

4.1. Participants

The study population is the 250 former students of the MCCT of CGIE. The sample consists of 109 people who completed a survey and were consulted about the impact of the MCCT for training in the commercialization and development of new technology-based companies.

4.2. Instrument

A survey prepared and conducted by Dr. David Gibson of the IC^2 of The University of Texas at Austin from April to June 2018 collected the information. The survey is used due to the number of former students, and their geographical location in different parts of the country, this survey allowed receiving a significant amount of responses. On the other hand, according to the research design, which follows a case method that defines categories and subcategories of analysis, the data collected through open-ended questions gave extensive information about people's thought.

The instrument consists of 35 questions (Appendix A), of which the first ten correspond to the alumni's personal information, such as name, graduation year of the Master's degree, gender, age, address, other studies, and current work. There are six Likert-type questions in which the participants are asked to provide, on a scale of 1 to 5 (1 = Nothing, 2 = Very little, 3 = Somewhat, 4 = Much, 5 = Very Much), their opinion on aspects related to the contribution of the Master's degree to their professional career, the relation of their current position with entrepreneurship, help from mentoring, and relationships generated in the Master's degree with their professional opportunities.

Additionally, 15 open-ended questions were included to deepen information about the experiences and learning of the alumni once they had completed the Master's degree program. For example, how has the Master's degree affected professional and business development? What was the focus of the project proposed during the Master's degree? What were the biggest challenges for the launch of that project? Have you participated in other ventures or technological transfer events related or unrelated to the Master's degree? What was the origin of the business idea? What is the size of the company? Also, what is the most significant benefit obtained? According to the qualitative research approach, the data collected from open-ended questions were taken for deeper analysis of the opinions of the participants, to answer the research question.

4.3. Analysis of Results

To analyze the answers of the survey, they were identified as ideas or concepts to define subcategories of analysis [45]. The review was done in the MAXQDA 12 software, to codify the answers expressed by the students and review the subcategories that emerged from the data. The categories and subcategories of analysis are in Table 1.

Table 1. Categories and subcategories of analysis.

Categories	Subcategories
Types of projects, including the types of projects developed during the Master's degree.	Projects: Product innovation Process innovation
Challenges faced: the main problems encountered for the launch of business ideas.	Challenges: Definition of the target market Viability of the product Legal aspects Economic resources
Impact of the Master's degree on professional and business development. This category refers to how the specific courses and knowledge acquired in the Master's degree and the faculty helped the alumni to develop professionally.	Application in the current job Improve knowledge Vision change Improve teaching practices Create a new company
Origin of the business idea and initial capital, establishing how participants conceived their business or technology and how they obtained the seed capital for their venture.	Origin of the business idea: Market and customer needs Share experiences with others Personal and professional experience Initial capital
Benefits of the MCCT program, indicating the most significant benefit perceived by the students when taking the Master's degree.	Benefits: Knowledge about technology transfer Networking Application to practical cases Impact of the teaching staff

5. Results

This section presents the results of the survey answered by 109 former students of the MCCT, the description of the sociodemographic data of the participants, and the match between the identified categories and subcategories of analysis.

5.1. Sociodemographic Data of the Participants

The group of people who answered the survey consisted of 72 men and 37 women. The average age was 42 years old, and 63% of the respondents said they had completed other postgraduate courses besides the MCCT. As for their positions before entering the MCCT program, 20% were researchers, 35% were professors and employees from universities, 20% were managers and directors in national and multinational enterprises, and 25% were entrepreneurs. Of the interviewees, 7% said they had become entrepreneurs after the Master´s degree. At the time of conducting the study, 58% had changed their activity, 7% indicating that they were entrepreneurs and that they were not entrepreneurs before the master´s program. Thirty-seven percent lived in Nuevo León and the rest in different states of Mexico. Finally, 60% of participants said they had participated in technology transfer events before or during the launch of a company.

5.2. Categories

This section presents each category found in the opinions of the former students from the Master´s program.

5.2.1. Types of Projects

During the Master´s program, students develop a commercialization project, bringing what is taught into practice by the students accompanied by the guidance of the teachers. To maintain confidentiality in the survey, answers regarding the developed ideas in the program are described in general terms. In this case, the types of projects developed were mostly oriented towards technology-based companies with new ideas and technology transfer, or companies already developed and implementing new methodologies.

Product innovation: some of the projects were the development of clean technologies, such as solar panels, the creation of biodegradable products, and environmental protection. Others included technologies for the food sector, agricultural, social, health, energy, electronics, biotechnology, nanotechnology, education, different types of software, and consulting.

Process innovation: In addition to innovation in products, there was also innovation in the process of methodologies, manufacturing, licensing, and marketing of new or existed products. Some of the students reported having satisfactory results: "the business focus of our project was to grow a company with a new branch within the business, which until now has been excellent since the owner of this technology continues to grow in the number of clients" (I30). However, some of the students could not apply the idea because of a lack of support from the company where it was going to be implemented, or because other colleagues did not continue with the initiative: "carry out an internal project to develop new technology. The project was proposed to the company, but there was no financial support for its execution (the company was where a teammate worked)" (I64).

> *Through the MCCT, I did not have the opportunity to focus on my business proposal. However, I had the opportunity to glimpse the route of the process that I had to implement the business opportunity in various technologies developed as a researcher.* (I35)

5.2.2. Challenges Faced

Definition of the target market: Among the difficulties in developing their ideas into practice, interviewees considered market definition and determining the price of the product or service to be challenges: "The limited market and the difficulty of identifying a niche with business potential, in addition to an expensive product" (I7); "the challenges were to find the size of the market, since the software was already in use" (I93).

Viability of the product: Students found problems in evaluating the feasibility of the products, little possibility of commercialization, lack of information about the technology, outdated information, and not identifying that there were other more advanced technologies.

Legal aspects: Other difficulties, such as defining strategies and lack of distribution channels, as well as legal aspects, especially in the field of medicine, information, intellectual property, registrations, and patents were mentioned as follows: "create a business model acceptable to the market and with adequate profitability, as well as diversify technology applications. Another complicated task was decision-making regarding negotiating the licenses" (I29). "That companies are afraid to try new things, are not very identified with innovation and technology, and many companies do not see the need to go hand in hand with these concepts" (I27).

> *To understand the technology and the degree of development of the same, to be able to decide if it was or not ready to be commercialized, besides the valuation of the same one. On the other hand, the treatment related to intellectual property, due to the zeal of the researcher who was not willing to discuss the possibilities with the team.* (I53)

Economic resources: Economic aspects were also mentioned, such as having few resources or difficulty finding seed capital.

5.2.3. Impact of the Master's Degree on Professional and Business Development

Application in the current job: the impact on professional development was noticed, as: "much of the acquired knowledge has helped me perform better in my new position in the organization, understanding situations in a better way" (I53), "I collaborate with a work team at a national level, working on the science and technology commercialization model, as well as the regulation for linking and innovation activities I am a recurrent guest at workshops and competitions for innovation and entrepreneurship" (I54); "thanks to the fact that I studied the MCCT, I could be in charge of different areas related to entrepreneurship in my work, and from there my professional growth began" (I66). As can be noted from the responses provided, students could apply the knowledge learned in the courses to their daily lives.

Improve knowledge: the interviewees said they obtained learning, such as knowledge about technological development and innovation, the commercialization of created products, intellectual property, patents, and utility models. As they mentioned: "I learned how to complement the process of research and generation of knowledge with the commercialization of the products generated" (I83), "it has helped me a lot concerning my professional development, teamwork, strategy, product, models, technology, patents, legal, and relationships. I feel that it is the side that I needed to develop" (I3).

Vision change: participants expressed that in the Master's degree, they were given a new perspective to look for solutions to the problems, as well as to use the knowledge to generate valuable products for the market: "this Master's degree opens your vision about the needs of the environment and helps you to understand that everything can be achieved by carrying out a good implementation plan. I apply it a lot, looking for new things and new solutions to what is presented day by day" (I30), "with the vision developed after acquiring the knowledge, I have a different perspective on addressing different problems and visualizing solutions" (I26). This change of vision and the knowledge acquired also moved former students to improve teaching practices and to teach others to develop businesses with these methodologies.

Improve teaching practices: some participants are applying their knowledge to promote entrepreneurship with their students, using them in courses they develop to generate projects based on technology and innovation, which allows them to extend the scope of the content seen in the Master's degree to other contexts.

> *I continue reading books related to the topics examined in the MCCT, and I have incorporated some practices of teachers in my classes. Interest in science, technology, transfer of knowledge and technology, intellectual property, risk analysis, marketing, finance, and entrepreneurship, were not of my interest and now they are. I force myself to continue participating in projects where these issues take place.* (I54)

Creation of new companies: after the Master's degree, the former students had carried out several ventures, such as software development companies, food products, technological developments, technology transfer offices, educational services, recruitment of personnel, public transport, intra-enterprise projects, family businesses, consulting, and other ongoing projects. As was mentioned by the entrepreneurs: "I am currently starting a technology-based venture and I have applied the knowledge of MCCT at all times"(I27), "the position I currently hold and my area of academic performance are highly related to the momentum in the creation of technology-based companies, technology transfer, innovation, and entrepreneurship. Currently, one of the academic programs has a specialty in Technological Innovation" (I42).

5.2.4. Origin of the Business Idea and Initial Capital

Market and customer needs: Typical responses were that the developed idea responded to a market need and customer demands, and this was recognized thanks to observation: "from the observation and analysis of my day-to-day work, as well as the identification of a need to be able to monitor performance efficiently in order to make quick decisions in a very demanding food product development environment" (I3), "of the ideas that arose when we were looking for the project and seeing an unmet need in the market" (I15), "we generated it by noticing the need of clients located in Nuevo León" (I21).

Share experiences with others: also, the origin of the business idea was thanks to the opinions of colleagues in the Master's degree, or other ideas that they were developing in their companies and had decided to continue as a study project. For example, one of the interviewees commented: "it was not my technology; we transferred technology from universities in other countries" (I7).

Professional and personal experiences: these experiences helped them to determine which products or services to offer to the market. As they commented: "the idea came when I was working as a professor at a university" (I8), "it was circumstantial when we enrolled our first-born in a school" (I5). Sharing experiences was also a reason for the conception of business ideas. Interviewees mentioned that this originated from talks, in the courses, about reviewing opportunities with other colleagues from the industry or sector. In the end, the entrepreneur is the person who has the idea and develops it.

Initial capital: In this category, the primary sources of business ideas were responding to market needs, to the requirements of clients, from sharing with others and from their personal and professional experiences. Most of the resources came from their funds, the government and private initiative, or a combination of these. They also came from partners, angel investors, family, and friends.

5.2.5. Benefits of the MCCT Program

Knowledge about technology transfer: the interviewees stated that the main benefit obtained from the program was having learned how to bring ideas to the market through knowledge of the methodologies learned in the Master's degree: "learn how to create a strategy, how a business works, how the teams interact in order to create a successful launch, and develop my inspirational, persuasive leadership skills and bring others with me" (I15).

Networking: another valuable element was networking, which allowed them to share the ideas generated with colleagues and professors, as well as to associate the acquired knowledge with real experiences of entrepreneurship, expanding their vision. In this sense, one of the interviewees stated: "improves the vision of the scope and potential (that we still have to do), of the real transfer processes and the path towards the foundation and growth of technology-based companies, and definitely, the colleagues and staff" (I23), "as I commented, it changed the way of seeing things and of being conformist, in the way I work and in my entrepreneurial activities" (I29).

Application to practical cases: the acquired knowledge is highly valuable for application to their environments, as mentioned by former students: "the knowledge, methodologies, and successful practices of how to do technology transfer. I am working to promote new internal policies and procedures and the culture of the rest of the company's staff" (I22); "definitely specialized knowledge in various areas associated with the creation of projects and businesses based on knowledge, but just as important is the collaboration network that was formed in our cohort" (I35).

> *The greatest benefit that I have obtained has been the learning, knowledge, and implementation of successful methodologies to research towards the development of innovative products that have a social and economic impact. I believe that this will only be achieved if you can work in synergy with the main actors in the whole value chain in which even the MCCT'S companions have a presence and collaborate with them effectively following appropriate guidelines of the organization, communication, and legal aspects.* (I53)

As interviewees indicated, the networking and the interaction with colleagues and professors were of great value.

Impact of the teaching staff: respondents mentioned that the transmitted experiences helped to improve the way of making decisions, and they learned from teachers how to analyze market opportunities, how to develop skills for their projects, and the importance of teamwork. Participants stated the transfer of knowledge of methodologies taught in classes to their current activities. Methods such as Quicklook, use of simulators, marketing, intellectual property, interview techniques, persuasion, and decision trees have been applied after the courses.

As comments, they expressed that: "the methodologies of the teaching process of all the teachers of the MCCT is different and of very good quality; I have used the best of each one to bring to the practice to my daily professional activities"(I52), "here are many examples, but to name one of them was the Intellectual Property class, where the professor showed great experience and knowledge in that area that moved me to learn more about it and now is one of my favorite topics" (I59). "I have been able to apply knowledge and experiences in activities of a different nature that are part of my functions, from applying the methodology of risk analysis to soft skills such as writing a persuasive proposal" (I86).

Finally, as a reflection of the application of these methodologies and knowledge, the interviewees think that Mexico should continue towards the development of technologies, considering that in the field of technology transfer, innovation is incipient and scarce in this country:

> *The practices and methodologies are very successful. I thought it would be very easy to apply them in Mexico, but experience has shown me that although there is more talk about technology transfer, a generalized culture of innovation and entrepreneurship is needed, mainly between research centers and industry.* (I28)

6. Discussion

The development of human capital is essential to enable innovative processes to impact the economy of a country. This influence is possible if education promotes the generation of ideas and ventures [15]. Several studies have criticized higher education institutions for not preparing students with the necessary innovation skills, since traditional forms of teaching such as reading, evaluating through memory, and working individually rather disfavor them [18,19].

Methodologies in the MCCT allow the advancement of technology-based entrepreneurship and entrepreneurial skills in students. Thanks to the search for value propositions in the use of technologies, entrepreneurs find applications that solve problems. In this case, the student becomes a relevant actor in contributing to the solution of environmental issues and collaborates in economic development [25].

The teaching–learning processes of the MCCT contain meta-innovations and elements of active learning, thanks to the use of the *Think and Do* methodology, participation in interdisciplinary collaborative projects, and with the support of expert teachers [20].

The learning has an impact on the entrepreneur that is recognized by the surveyed students, especially in a change of vision where they use what they learned in the context in which they work. Also, as Lehto and Penttilä [24] state, meta-innovation processes allow participants to develop capacities to participate in an increasingly globalized world. The international collaboration of professors from The University of Texas at Austin exposes Mexican students to other experiences and prepares them for internationalization.

When analyzing the context, the objectives of the Master's degree are aligned with the State Development Plan of Nuevo León [35], especially in its work to strengthen the creation of companies based on technology, the development of programs for creating these companies, the formation of entrepreneurial talent, and internationalization. Requiring the students to create new companies also prepares them for the challenges that arise when putting ideas into practice. Students recognize the difficulty of satisfying the needs of customers and the market, little information about the use of technology, and, in some cases, the challenge in obtaining resources. Therefore, it is suggested to continue with the virtuous circle of entrepreneurship by increasing the link with other actors of the innovation ecosystem, as recommended by Maroufkhani et al. [31].

The importance of these findings is that they allow for identifying good practices in the role of higher education to create synergies among actors of the innovation ecosystem [9,10]. Also, it contributes to the discussion of the functions of a university in a transnational context, considering that the Latin American region may benefit from these initiatives of integration with universities that have developed the theme of entrepreneurship and innovation for a long time [4]. Finally, understanding dynamic factors and roles will empower actors to generate innovation and sustainable practices [38].

7. Conclusions

This study shows that the State of Nuevo León in Mexico has the necessary conditions for the development of companies based on science and technology. The long-term development plans with a clear vision, the required infrastructure for their achievement, and the participation of actors of the innovation ecosystem, are favorable conditions to achieve the goals that lead to the economic development of the state and the country. However, according to the results shown by the PECTI 2016–2021, it is still necessary to improve to reach the expected levels of development and innovation. Therefore, the role of the CGIE through the MCCT and the activities it develops can help to achieve them.

In the presented analysis, it was possible to determine that the students developed innovation and entrepreneurship skills. Also, they applied what they learned to their business ideas, in other companies and training processes for other entrepreneurs. Besides this, they were able to create a network with colleagues and teachers that allowed them to improve and implement their ideas.

Regarding the question of how higher education institutions can affect the development of entrepreneurship and innovation, the analyzed case study shows that the methodologies evolved in the MCCT allowed students to develop skills for innovation, technology transfer, the creation of new companies, the commercialization of new ideas, and entrepreneurial abilities. The application of these methodologies has favored the emergence of sustainable initiatives within the students' projects. Moreover, they have allowed the generation of companies that help other entrepreneurs to develop solutions to environmental and social problems.

As the primary concern, the former students pointed out that there is limited development in the field of technology transfer and commercialization in Mexico, a problem faced by other Latin American countries.

The role of CGIE is fundamental for improving these results through the training of human capital in innovation, and the development of ideas to solve these types of problems through new technologies. So, linking with other academic institutions and industry can increase the impact of the specialists trained at the center. For the local government, it is also an opportunity to learn more about these entrepreneurship training programs to apply them in a larger population, implementing more business ideas. For industries, they can also give ideas to the students. Learners can develop solutions they need, and businesses can collaborate with the employment of these professionals.

Other countries in Latin America can emulate good practices presented in this case study. Although some students are from the same geographical area, there are also learners from different states of the country. In this circumstance, training can improve the results of the impact and economic growth at the state, the country, and regional levels.

For future studies, it is suggested to analyze in quantitative terms the value of the companies created in the Master's degree and the contribution of these companies to the state and country Gross Domestic Product (GDP). It is also recommended to investigate success stories for knowing in more detail about the applied practices of the MCCT and the social problems solved by these companies. Another suggestion would be to examine the actions of other participants of the innovation ecosystem in Nuevo León, such as accelerators, research centers, and technology parks, and their results for economic development.

Finally, continue analyzing the role of education for entrepreneurship and innovation, and its implementation through projects applied to the solution of real problems that result in high-impact technology companies, with the dissemination of good practices such as those presented in this case study. At a conference held in the city of Dallas, Texas in 1997, George Kozmetsky, founder of the IC^2 Institute, gave his vision of the impact of technology in the 21st century and of the transformation towards a knowledge society:

> *Business leadership has the ability to manage the value-added chain, the technology chain, and knowledge innovation chains, simultaneously. The knowledge innovation chain is "the creation, evolution, exchange, and application of new ideas into marketable goods and services for the excellence*

> *of an enterprise, the vitality of a nation's economy, and the advancement of society as a whole. It is the velocity of change. In short, the knowledge society breaks the old 1990s MBA. Enterprise creation and innovation is an emerging competitive digital technology-based economy realizing the value of interdependencies rather than close-kept intellectual property assets of the last twenty-five years*. [47] (p. 21)

All these elements are still valid for the formation of human capital and entrepreneurial talent, an essential component to impact the economic and social development of the region.

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Appendix A

MMCT impact survey.

Q1. What is your full name?
Q2. What year did you graduate from MCCT?
Q3 What is your gender?
Q4. How old are you?
Q5. Besides MCCT, do you have other degrees? What are they and where was obtained?
Q6. What organization did you work for? and what was your position before entering the MCCT program?
Q7. What city do you currently live?
Q8. What organization do you currently work?
Q9. What is your current position/title?
Q10. What is your contact information (mail, phone)?
Q11. How much has MCCT experience helped your professional career? 1□ 2□ 3□ 4□ 5□
Q12. How directly your current position relates to entrepreneurship and business development? 1□ 2□ 3□ 4□ 5□
Q13. How much have the specific courses and knowledge of MCCT to your professional development and business experiences? 1□ 2□ 3□ 4□ 5□
Q14. Please explain your answer.
Q15. How the mentoring and connections of the professors and MCCT staff have helped you with your professional opportunities? 1□ 2□ 3□ 4□ 5□
Q16. Please explain your answer.
Q17. How much have you benefited from your connections with colleagues from class in your professional and business opportunities? 1□ 2□ 3□ 4□ 5□
Q18. Please explain your answer
Q19. What was the business focus of your MCCT project? Please explain your answer.
Q20. What were the biggest challenges for the launch of your company during the MCCT program? Please explain your answer.
Q21. Do you have participated in other ventures (related or not to MCCT) after graduating from the MCCT program? Please explain and Name the companies.
Q22. Have you participated in a technology transfer event or the launch of a company? Yes□ No□
Q23. How long had/has the company existed? (Years and months)

Q24. Where did your technology business idea come?
Q25. Where did the seed capital come?
Q26. How many employees did your company have or have now?
Q27. The company still exists or was sold or licensed to another company?
Q28. Who are the main clients of the business/technology?
Q29. Do you keep in touch with other members of your project team of MCCT? Please explain your answer. Yes□ No□
Q30. How often do you communicate with your colleagues in the generation?
Q31. With how many of your colleagues from other generations of MCCT, you communicate?
Q32. Indicate all the forms of communication do you use to contact your MCCT partners?
Q33. Did have left a continuous impact on the knowledge and experience of MCCT teachers in your professional development? 1□ 2□ 3□ 4□ 5□
Q34. Please give a specific example.
Q35. What has been the most significant benefit do you have obtained from the program MCCT? Please explain your answer.

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Postgraduate Education of Board Members and R&D Investment—Evidence from China

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Abstract: Increasing research and development (R&D) investment has been a common strategy to advance the sustainable development of economy and competitiveness across the world. Instead of external determinants, exploring the influence of internal factors such as the characteristics of board members is an important topic, yet under-researched. This article aims to reveal whether a firm's R&D investment is related to the directors' postgraduate education experience. Further, we want to explore whether this relationship shows heterogeneity in different industrial environments. We analyzed information from a sample of 1374 listed companies in China using descriptive statistics, ordinary least square (OLS) regression and instrumental variable (IV) estimation, and came to the following conclusions: First, the percentage of directors with doctorates significantly increases the chance of investing R&D activities. Second, in the second industry, the higher the proportion of postgraduate education degree holder as directors in a firm, the more expenditure the firm invests in R&D activities. Yet, there is no such association in the third industry. Finally, if a capital-driven strategy is adopted, directors with a master's degree tend to reduce R&D investment in IT companies. Findings from this research not only enrich innovation management theory, upper echelon theory, and human capital theory, but also provide insights for corporate governance and national sustainable innovation.

Keywords: postgraduate education; education level; discipline background; graduation institution; R&D investment

1. Introduction

Under the background of new scientific and technical revolution and accelerated advancement of industrial reform around the world, innovation, as the first driving force leading social and economic development, is pivotal to a country's sustainable development and rebuilding world competition pattern [1–3]. As a result, increasing research and development (R&D) investment and advancing innovation have been common strategies of the world's main economies, especially those emerging markets [4–6]. According to Science & Engineering Indicators (2018 Digest) issued by National Science Foundation of the United States, R&D investment in the USA, Japan, Germany, France, China, UK, and South Korea tended to rise generally after 2000, and the rising tendency in China was remarkable. China, within ten years, successively surpassed France (2001), Germany (2004), and Japan (2009) and developed into the world's second-largest county in R&D investment following the USA [7]. Enterprises are the main driving forces for research and development. By 2017, the proportion of enterprises' R&D investment in total investments of China reached 77.6% [8], which was significant for China to promote a development strategy driven by innovation and build an innovative county. However, in China, enterprises typically invested less in R&D activities than those in the USA. In 2017, average R&D investment of enterprises in China was less than 3%, far lower than 6% of the USA [9]. In particular, as current Sino-US trade friction aggravates, strengthening the function of enterprises in research and development and national scientific and technical innovation will be a key strategy to tackle new challenges in the new era.

What factors will influence enterprises' innovation on research and development? Previous research has found that influential factors of research and development include external economic and political environments [10], such as macroeconomic volatility [11], interest rate marketization [12], political instability [13], judicial system [14], and the nature of business [15]. However, according to many studies since the innovation theory was proposed by Joseph Schumpeter, enterprises do not focus on external influencing factors only. Instead, internal factors are also be considered [16–18]. Especially, the upper echelons theory proposed in 1984 brought the influence of observable and unobservable features into the view of researchers [19–21]. The former includes cognitive bases and values of senior management. The latter involves factors such as the level of education, age, and professional experience on corporate strategy. Postgraduate education is the main channel for cultivating advanced innovative talents [22]. Compared to employees with senior high school education or undergraduate education background only, staff with master's or doctoral degrees may have higher innovative awareness and stronger capacities in research and development due to their scientific research experience. When working in an enterprise or being promoted to directors, they may apply their postgraduate education to practical scenarios. This will prominently advance R&D activities of the enterprise and can be regarded as an important representation of social functions of postgraduate education.

In this view, the relationship between directors' postgraduate education experience and R&D activities of their companies has been a significant topic yet, under-researched. Our paper aims to fulfill this gap. The detailed objective of this paper is twofold. First, we aim to reveal whether a firm's R&D investment is significantly related to its directors' postgraduate education experience. Second, we aim to explore whether this relationship shows heterogeneity in different industrial environments. Based on a sample of 1374 companies in China, we examined the overall influence of directors' postgraduate education characteristics on their firm's R&D investment. We further investigated this correlation in the second industry and the third industry, respectively. Moreover, IT industry attracted particular attention during the analysis due to its massive R&D investment activities compared to other industries. This study contributes to related research both theoretically and practically

In terms of theoretical contribution, this paper enriches innovation management theory, upper echelon theory, and human capital theory. In contrast to prior innovation management research highlighting external determinants of corporate R&D innovation, our research finds that the higher the percentage of directors with a doctoral degree is, the more investment in R&D activities, providing the empirical evidence that internal factors from board of directors also matters. In line with the research from the perspective upper echelon theory, this paper pays attention to director's individual characteristics as well, especially educational characteristics. Our research findings indicate the association between a director's postgraduate education characteristics and a firm's R&D investment varies in different industry environments. In the second industry that mainly consists of industrial companies, the higher the proportion of postgraduate education degree holder as directors, the more expenditure in R&D activities. However, this correlation is not statistically significant in the third industry, which involves commercial, financial and real estate, public utilities, culture, education, sports, and IT companies. Through the lens of human capital theory, there is economic value embedded in the postgraduate education, which is justified in this paper in the respect of R&D investment. In addition to the positive impact of human capital on economic growth and R&D innovation that has been studied thoroughly, our contribution lies in unpacking the complexity in reality due to the certain attributes of both board directors and corporate developing strategies. Findings in IT companies confirm that if a capital-driven strategy is adopted, directors with master's degrees and economics and management background tend to reduce R&D investment.

In terms of practical contribution, research findings of this paper provide insights for the corporate governance at the institutional level and the sustainable innovation strategy at the national level.

Enterprises should realize the correlations between directors' postgraduate education characteristics and R&D investment, then adopt targeting innovative strategies, and through board staffing and configuring. National policy should also encourage universities to increase the availability of innovation and entrepreneurship education in the curricula system of postgraduate education for the achievement of sustainable innovation of a state.

The rest of this paper is organized as follows. The second part briefly reviews the relevant literature and several corresponding hypotheses drawn from previous research. The third part introduces the research methods, which include information about data used in this study and operationalization of variables. Results of descriptive statistics of variables are also presented in this part. The fourth section documents the research findings based on the ordinary least square (OLS) regression analysis and the endogeneity problem is treated through different methods. Apart from the overall influence, regression between different industries and within the IT industry are also employed. The next section shows the related discussion and conclusions emerging from this study. Possible implications, limitations, as well as future research directions are discussed in the last section.

2. Literature Review and Research Hypothesis

A large number of empirical studies have identified that highly educated top management teams, for instance CEOs, hold more of an open attitude toward innovation [23] and thus have a tendency to invest more in R&D activities [24]. Following this line of reasoning, directors, as the core decision-makers of a firm, may also play a central role in the innovative strategies of a corporate. Therefore, their characteristics may exert a profound influence on a firm's R&D activities as well. The relationship between directors' characteristics and a firm's R&D investment has attracted attention from several scholars so far. For example, the following studies identified that directors' gender affected the firm's R&D investment. Despite the common sense that women tend to be risk-averted, researchers have found that female directors in the boardroom actually invest more in R&D activities compared with their male counterparts [25–27]. Age is another determinant. Based on the data from the IT listed firms in China from 2007 to 2010, it was found that directors' age had a negative effect on the company's R&D investment [28]. Others claimed that positions which directors used to take also shaped the strategic decisions regarding R&D investment in a company [29,30]. For example, entrepreneurial finance experience and technical experience of directors in publicly traded biotech/pharmaceutical enterprises could significantly affect R&D investment [31]. Moreover, an increasing line of literature also provides empirical evidence that directors' educational background, a predominate indicator representing human capital, is associated with a firm's R&D investment [32]. Given the fact that directors in Chinese listed firms are basically master's degree holders [33], the director's postgraduate education experience deserves more attention. However, prior literature primarily captures directors' level of education, while their disciplinary background and graduation institution characteristics are largely ignored. This paper aims to fill this gap.

Although directors' postgraduate education experience has natural correlation to R&D activities of their companies, conclusions of existing related empirical research are not consistent. According to some studies, higher levels of education of directors will promote R&D investment in high-tech industries such as chemical, pharmaceuticals, and astronavigation. Furthermore, directors with a master's or a doctoral degree may lead their partners to focus on research and development [34]. However, according to a study based on 225 listed companies in the USA in the biotechnology and pharmaceuticals industry, not all directors with doctoral degrees focus on research and development [31]. One possible reason for their findings is that they count not only PhDs as doctorates, but also JD (Doctor of Jurisprudence), and MD (Doctor of Medicine). JD and MD are mainly practice-based instead of research-based, which may interfere the causality to a certain extent. Studies base on Taiwan companies found that the higher the level of director's education is, the more R&D investment will be made [32,35]. Therefore, the following research hypotheses are proposed regarding the education levels of board directors and their relationship with R&D investment in a firm:

H1a: *The higher the proportion of directors with master's degrees is, the more R&D investment will be made.*

H1b: *The higher the proportion of directors with doctoral degrees is, the more investment in corporate research and development will be made.*

In addition to levels of education, the disciplinary background of directors may have influence on corporate R&D investment. Students may form different cognitive bases, depending on their training received from fields of engineering, science, arts and humanities, and social sciences [19]. Directors with degrees in science or engineering fields focus more on technical advancement, research and development innovation, and add more investment to R&D activities [36,37]. In addition, directors with background in economics and management may see economic values from innovation for research and development easier and focus more on R&D activities, depending on their knowledge of effectively controlling risks of innovation investment. Therefore, for the discipline background of directors with a postgraduate degree, research hypotheses have been proposed as follows:

H2a: *The higher the proportion of directors with degrees in science and engineering is, the more R&D investment will be made.*

H2b: *The higher the proportion of directors with degrees in economics and management is, the more R&D investment will be made.*

Institution of graduation is another possible factor that might have influence on directors' attitudes towards R&D investment. A study [31] based on listed companies in the United States indicated that directors graduating from Ivy League institutions are more likely to increase investment in corporate R&D activities as compared with those graduating from non-Ivy League institutions, likely due to more exposure to leading research and active communication with elite scholars during their graduate programs.

In China, more and more research-intensive universities are making efforts to integrate scientific research while cultivating students. In some top universities, postgraduate students are provided with opportunities to participate in scientific research, even achieving some world-level research results. Therefore, it is necessary to empirically examine whether directors who graduated from China's well-known universities pay more attention to corporate research and development. In addition, some studies also argue that entrepreneurs who graduated from institutions overseas will present the 'knowledge spillover effect' after returning to China and are likely to value innovative entrepreneurship, and research and development higher [38]. With more and more overseas postgraduate education degree holders returning, further empirical evidence is needed for the claim that directors with degrees granted by institutions outside of China are more likely to invest more on R&D activities. Therefore, for directors with master's or doctoral degrees, research hypotheses have been proposed as below:

H3a: *The higher the proportion of directors graduating from elite colleges and universities is, the more investment on research and development will be made.*

H3b: *The higher the proportion of directors graduating from overseas institutions is, the more investment on research and development will be made.*

3. Methods

3.1. Data

Data used in this research were collected from two sub-databases of the China Stock Market and Accounting Research (CSMAR), Shenzhen, China database, which contains comprehensive information of all listed companies in China in its 38 sub-databases. This project collected data from two sub-databases: role characteristics database for detailed information about board directors, and research and development sub-database for detailed expenditure on R&D activities in those companies. The data utilized in this paper were collected through the following steps: 1) We extracted the education characteristics of board directors for the 3752 listed companies in China from the role characteristics subset of the CSMAR database. 2) We extracted the R&D expenditure, board size, and asset-liability ratio for the 3752 listed companies in China from the research and development subset of CSMAR database. 3) We matched data from the first two steps and removed companies that miss information for core variables that we are interested in, including R&D investment, industry type, asset and liability of enterprises, educational level, disciplinary background, graduation institution, and working experience of directors, which fields a final list of 1374 companies.

In the first step, we gathered original data from two CSMAR sun-databases, and 3752 companies was included. One is the role characteristics of listed company sub-database, from which we extracted directors' postgraduate education characteristics. The other is the research and development innovation sub-database, from which we extracted the firm's R&D investment, board size, asset-liability ratio, etc. The expiration date of data collection was 31 December 2017. In the second step, we matched the director's individual characteristics with the firm's financial data. In the third step, deleting observations if the core variables were missed. Finally, 1374 companies consisted of our sample. Table 1 reports the comparison between sample and population in terms of asset-liability ratio and industry distribution. Chi-squared test suggests there is no significant difference between sample and population. Therefore, there are reasons to believe that our sample represents well. 'GB/T 4754—2017' in China classifies industry into 20 categories. According to research needs, this paper recombines them into 7 groups. There are commercial companies, financial and real estate companies, public utility companies, companies in agriculture, forestry, animal husbandry, and fishery, industrial companies, cultural, educational and sports companies, and IT companies, respectively. In general, our sample includes 24 commercial companies, 16 financial and real estate companies, 67 public utility companies, 11 companies in agriculture, forestry, animal husbandry, and fishery, 1066 industrial companies, 42 cultural, educational, and sports companies, and 148 IT companies.

Table 1. Comparison between sample and population (%).

Asset-Liability Ratio			Industry			R&D Investment		
	Sample	**Population**		**Sample**	**Population**		**Sample**	**Population**
< 0.01	0.00	0.00	CC	1.75	4.92	0.01–10.00	91.35	89.52
0.01–0.20	21.62	17.77	FR	1.16	6.21	10.01–20.00	6.60	8.08
0.21–0.40	34.43	31.93	PU	4.88	9.78	20.01–30.00	1.47	1.67
0.41–0.60	30.13	29.68	AFAF	0.8	1.15	30.01–40.00	0.34	0.51
0.61–0.80	12.30	15.55	IC	77.58	67.55	40.01–50.00	0.10	0.07
0.81–1.00	1.09	4.64	CES	3.06	3.1	50.01–60.00	0.07	0.07
≥ 1.01	0.44	0.43	IT	10.77	7.28	60.01+	0.07	0.07
$\chi 2 = 3.68$, $p = 0.596$			$\chi 2 = 8.09$, $p = 0.231$			$\chi 2 = 1.39$, $p = 0.967$		

Note: CC: commercial companies; FR: financial and real estate companies; PU: public utility companies; AFAF: companies in agriculture, forestry, animal husbandry, and fishery; IC: industrial companies; CES: cultural, educational, and sports companies; and IT: IT companies.

3.2. *Definition of Variables and Statistical Techniques*

CSMAR uses absolute value and relative value to quantify the investment in research and development. The absolute value refers to the total amount of R&D investment within a certain time range, while relative value refers to the ratio between the total amount of R&D investment and the total sales [38–40], total assets [41–43], or the employees' number [44,45] within a certain time range. This study mainly focuses on the relative degree of attention paid to innovation for research and development by listed companies. Taking into account the availability of data, and the various sizes of companies, this project operationalized R&D investment as the proportion of total amount of R&D investment normalized by total sales.

This paper examines the postgraduate education of directors from the perspectives of education level, discipline background, and graduation institution. This paper uses the proportion of directors with master's degrees and proportion of directors with doctoral degrees as the two indicators of education level. Discipline background is quantified using: the proportion of directors with degrees from science and engineering field and the proportion of directors with degrees from economics and management. Graduation institution of directors is measured upon: the percentage of directors graduated from C9 universities and the percentage of directors graduated from overseas institutions. The C9 is China's first collegiate league among elite universities. It was launched in October 2009. The alliance members include Peking University, Tsinghua University, Fudan University, Shanghai Jiaotong University, Nanjing University, Zhejiang University, University of Science and Technology of China, Harbin Institute of Technology, and Xi 'an Jiaotong University. The postgraduate education characteristics of directors is not the only potential factor of R&D investment. Directors' working experience, corporate asset-liability ratio, industry type, and total assets are adopted as control variables in this study.

All the variables in this paper and its definition are listed in the Table 2.

Table 2. Variable definition.

Variable	Definition	Scale of Measurement
	Dependent variable	
R&D investment (%)	R&D expenditure normalized by total sales	continuous variable
	Independent variables	
PMD	proportion of directors with master's degrees	continuous variable
PDD	proportion of directors with doctoral degrees	continuous variable
PEM	proportion of directors with degrees from economics and management	continuous variable
PSE	proportion of directors with degrees from science and engineering	continuous variable
PC9	percentage of directors graduated from C9 universities	continuous variable
POI	percentage of directors graduated from overseas institutions	continuous variable
	Control variables	
RDE	percentage of director who has R&D work experience	continuous variable
ALR	asset-liability ratio	continuous variable
Industry	industry type	categorical variable, CC = 1, FR = 2, PU = 3, AFAF = 4, IC = 5, CES = 6, IT = 7
Asset	natural logarithm of total asset	continuous variable
	Instrumental variable	
IFRD	if board members have engaged in R&D work	dummy variable, 1 if directors have engaged in R&D work

Note: CC: commercial companies; FR: financial and real estate companies; PU: public utility companies; AFAF: companies in agriculture, forestry, animal husbandry, and fishery; IC: industrial companies; CES: cultural, educational, and sports companies; and IT: IT companies.

This paper uses basic descriptive statistics to explore the data first. OLS regression is used to test the influence of directors' postgraduate education characteristics on the firm's R&D investment overall and by industry. Taking into account potential endogeneity issues, more control variables were added and IV2SLS regression was employed to ensure the robustness of the result.

3.3. Descriptive Statistics

Table 3 shows the descriptive statistics for all variables of interest in this paper. In 2017, the average proportion of R&D investment in listed companies of China reached 5.10% and the maximum proportion of R&D investment reached 76.35%. In terms of directors' postgraduate education level, nearly half (48%) of directors in listed companies have master's degrees and 24% have doctoral degrees as their highest degrees. In terms of discipline background, approximately 46% of directors got degrees from economics and management and 15% from science and engineering. In terms of graduation institutions, about 18% of directors graduated from C9 institutions in China and 15% from overseas institutions. In addition, roughly 24% of directors were engaged in research and development positions once.

Table 3. Results of descriptive statistics for each variable.

Variable	N	Mean	Standard Deviation	Min. Value	Max. Value
			Dependent variable		
R&D investment (%)	1374	5.10	5.29	0	76.35
			Independent variables		
PMD	1374	0.48	0.37	0	1
PDD	1374	0.24	0.32	0	1
PEM	1374	0.46	0.38	0	1
PSE	1374	0.15	0.26	0	1
PC9	1374	0.18	0.29	0	1
POI	1374	0.15	0.28	0	1
			Other variables		
RDE	1374	0.24	0.31	0	1
ALR	1374	0.38	0.20	0.02	1.63
Industry	1374	5.04	1.02	1	7
Asset	1374	22.05	1.31	18.11	28.51
IFRD	1374	0.49	0.50	0	1

R&D investment amount varies by industry. As shown in Figure 1, the selected companies on average invested about 5.10% of the total sales on R&D activities. The IT industry has the highest (10.57%) R&D investment ratio among all industries, followed by industrial companies (4.74%) and cultural, educational, and sports companies (4.32%). Commercial companies spent the least (0.92%) among all industries on R&D activities.

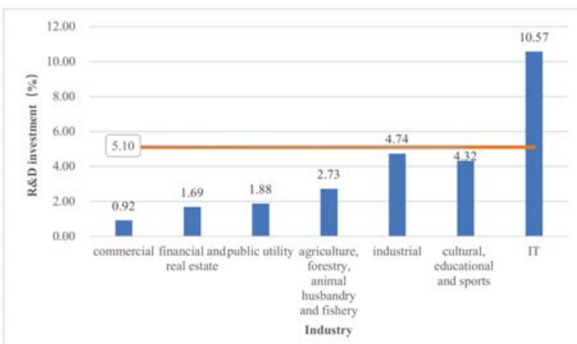

Figure 1. Distribution of R&D investment for listed companies by industry.

Table 4 presents the distribution of directors' postgraduate education characteristics in listed companies by industry. In term of education level, the proportion of directors with master's degrees in listed companies is higher than that with doctoral degrees across industries. The largest gap of this exists in agriculture, forestry, animal husbandry, and fishery companies: where the proportion of directors with doctoral degrees is the lowest and the proportion of directors with master's degrees is the highest among all industries. The proportion of directors with doctoral degrees in public utility companies is the highest. In term of discipline background, the proportion of directors majoring in economics and management in each industry is far higher than that in science and engineering, which is most prominent in agriculture, forestry, animal husbandry, and fishery companies. In term of graduation institution, the percentage of directors graduating from C9 universities and overseas institutions in agriculture, forestry, animal husbandry, and fishery companies is the highest. The lowest figure for directors graduating from C9 universities and graduating from overseas institutions appears in industrial and commercial companies, respectively.

Table 4. Distribution of directors' postgraduate education characteristics in listed companies by industry.

	Total	CC	FR	PU	AFAF	IC	CES	IT
PMD	0.48	0.55	0.62	0.46	0.73	0.47	0.43	0.53
PDD	0.24	0.24	0.19	0.29	0.18	0.24	0.25	0.19
PEM	0.46	0.65	0.58	0.49	0.79	0.46	0.36	0.42
PSE	0.15	0.05	0.14	0.11	0.09	0.15	0.19	0.20
PC9	0.18	0.23	0.23	0.19	0.24	0.17	0.20	0.19
POI	0.15	0.13	0.20	0.17	0.24	0.16	0.16	0.13

Note: CC: commercial companies; FR: financial and real estate companies; PU: public utility companies; AFAF: companies in agriculture, forestry, animal husbandry, and fishery; IC: industrial companies; CES: cultural, educational, and sports companies; and IT: IT companies.

4. Results

4.1. Overall Influence of Directors' Postgraduate Education Characteristics on a Firm's R&D Investment

The OLS regression is applied to explore the influence of directors' postgraduate education characteristics on R&D investment in the listed companies. Model 1, model 3, and model 5 are benchmark models that only include independent variables to reflect net influence of directors' education level, discipline background, and graduation institutions on a firm's R&D investment, respectively. Model 2, model 4, and model 6 include three control variables, i.e., corporate asset-liability ratio, industry, and the proportion of directors with work experience in R&D positions. Model 7 involves all the independent and control variables. Table 5 documents the OLS regression results.

As the regression results show, when control variables are introduced based on the benchmark model, the F value and R-value increase prominently, and the F value is statistically significant ($p = 0.00$). This indicates that the fitting and explanation degree of the model enhances significantly after the introduction of control variables. According to model 2, model 4, model 6, and model 7, the higher the proportion of directors with doctoral degrees is, the more investment in research and development will be made. This result fails to reject the hypothesis 1b. However, proportions of directors with master's degrees, director's discipline background, and graduation institution do not show significant impact on the amount of R&D investment in companies.

The regression coefficient of control variables also manifests the director's R&D working experience, a significantly positive relationship with the firm's R&D investment. However, asset-liability ratio exerts a significantly negative effect on R&D investment. In addition, regression results shown in Table 3 also indicate the industrial heterogeneity of the influence of directors' postgraduate education characteristics on R&D investment in listed companies. Therefore, it is necessary to further run additional regressions by industry.

Table 5. OLS regression results of the influence of directors' postgraduate education characteristics on a firm's R&D investment.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
PMD	0.31	0.17					0.14
	(1.04)	(0.65)					(0.53)
PDD	0.49 *	0.59 **					0.53 *
	(1.70)	(2.28)					(1.95)
PEM			−0.33	0.12			0.00
			(−0.88)	(0.36)			(0.00)
PSE			2.14 ***	1.01 *			0.74
			(3.46)	(1.87)			(1.36)
PC9					0.25	0.18	0.01
					(0.52)	(0.45)	(0.02)

Table 5. *Cont.*

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
POI					−0.31	0.01	−0.18
					(−0.63)	(0.03)	(−0.41)
Industry (CC as the reference group)							
ALR		−4.99 ***		−4.76 ***		−4.83 ***	−4.90 ***
		(−5.01)		(−4.64)		(−4.71)	(−4.94)
FR		1.38 **		1.38 *		1.48 **	
		(1.98)		(1.89)		(2.07)	
PU		0.70 *		0.82 **		0.84 **	
		(1.69)		(1.98)		(2.05)	
AFAF		1.86 *		1.67 *		1.74*	
		(1.89)		(1.72)		(1.77)	
IC		3.02 ***		3.02 ***		3.07 ***	
		(7.92)		(7.61)		(7.85)	
CES		2.38 ***		2.44 ***		2.54 ***	
		(3.78)		(3.90)		(3.98)	
IT		8.54 ***		8.54 ***		8.63 ***	
		(11.50)		(11.52)		(11.74)	
RDE		1.40 ***		1.27 ***		1.50 ***	1.21 ***
		(3.23)		(2.99)		(3.48)	(2.85)
Constant	4.67 ***	2.87 ***	4.92 ***	2.99 ***	5.10 ***	3.08 ***	2.88 ***
	(17.51)	(4.32)	(18.93)	(4.55)	(27.09)	(4.99)	(4.15)
N	1374	1374	1374	1374	1374	1374	1374
r^2	0.00	0.20	0.01	0.20	0.00	0.19	0.20
F	1.84	35.79	8.56	34.33	0.36	34.09	25.77

Note: CC: commercial companies; FR: financial and real estate companies; PU: public utility companies; AFAF: companies in agriculture, forestry, animal husbandry, and fishery; IC: industrial companies; CES: cultural, educational, and sports companies; and IT: IT companies. t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.2. The Influence of Directors' Postgraduate Education Characteristics on a Firm's R&D Investment by Industry

Giroud and Mueller have justified that the product market competition should be considered in order to determine the relationship between corporate governance and R&D policy [46]. Therefore, it is necessary to explore the relationship between directors' postgraduate education characteristics and a firm's R&D investment by individual industry since each industry may face different competitions. Due to the limited number of companies in some industries, this study further recategorized industries into the first industry (11 companies, including agriculture, forestry, animal husbandry, and fishery industry), the second industry (1066 companies, including industrial industry), and the third industry (297 companies, including commercial, financial and real estate, public utilities, culture, education, sports, and IT industry). The first industry was excluded from further analysis due to its small sample size.

The model settings for analyzing the second and the third industry are similar to that shown in Table 5. As shown in Table 6, in the second industry, the higher the percentage of directors with master's degrees and doctoral degrees, the more investment to corporate research and development, controlling directors' work experience in R&D positions, and corporate asset-liability ratio. However, the landscape in the third industry shows substantial distinctions: with the same variables controlled, no significant relationship between board directors' education characteristic and the RD investment of a firm was observed.

Table 6. OLS regression results of the influence of directors' postgraduate education characteristics on a firm's R&D investment by industry.

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
				The second industry			
PMD	0.56 **	0.69 **					0.68**
	(2.00)	(2.51)					(2.39)
PDD	0.57 **	0.62 **					0.56 **
	(2.09)	(2.26)					(1.98)
PEM			−0.05	0.23			0.05
			(−0.13)	(0.59)			(0.11)
PSE			1.67 ***	1.07 *			0.69
			(3.01)	(1.88)			(1.12)
PC9					0.08	−0.02	−0.29
					(0.17)	(−0.04)	(−0.60)
POI					0.02	0.11	−0.23
					(0.05)	(0.22)	(−0.46)
ALR		−4.20 ***		−3.85 ***		−3.90 ***	−4.13 ***
		(−6.02)		(−5.53)		(−5.62)	(−5.89)
RDE		1.52 ***		1.41 ***		1.64 ***	1.36 ***
		(3.62)		(3.16)		(3.93)	(3.04)
Constant	4.12 ***	5.22 ***	4.51 ***	5.57 ***	4.72 ***	5.79 ***	5.23 ***
	(15.98)	(14.51)	(17.18)	(14.72)	(25.78)	(17.27)	(13.09)
				The third industry			
PMD	−1.54	−0.98					−1.13
	(−1.58)	(−1.09)					(−1.23)
PDD	−0.14	−0.16					−0.19
	(−0.16)	(−0.20)					(−0.23)
PEM			−1.48	−0.96			−0.10
			(−1.10)	(−0.78)			(−0.26)
PSE			3.89 **	1.81			−0.77
			(2.05)	(0.99)			(−0.58)
PC9					0.57	0.49	2.46
					(0.37)	(0.35)	(1.25)
POI					−1.86	−1.10	0.38
					(−1.04)	(−0.67)	(0.25)
ALR (%)		−13.84 ***		−13.72 ***		−14.02 ***	−13.34 ***
		(−7.21)		(−7.16)		(−7.33)	(−6.87)
RDE		3.10 **		2.38 *		2.91 **	2.30
		(2.24)		(1.65)		(2.10)	(1.59)
Constant	7.67 ***	12.07 ***	6.49 ***	11.52 ***	6.63 ***	11.45 ***	12.21 ***
	(8.31)	(10.68)	(7.33)	(10.02)	(10.87)	(11.63)	(9.59)

Note: t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.3. Influence of Directors' Postgraduate Education Characteristics on IT Companies' R&D Investment

The R&D expenditure in the IT industry is almost two times the average level (seen in Figure 1), which plays a decisive role in the overall level of corporate R&D investment in China. Although the previous analysis on all companies indicates that directors' postgraduate education has no significant impact on R&D investment efforts in a company, it is still necessary to analyze this relationship for IT companies due to the large amount of R&D expenditure and distinctive business feature.

According to the regression results in Table 7, the percentage of directors with master's degrees has a negative correlation with R&D investment in the IT industry. That is, the higher the percentage of directors with master's degrees, the less money a company spends on R&D activities. Additionally, the percentage of doctoral degree holders on board, discipline background, graduation institutions, and previous work experience in R&D positions has no significant influence on R&D investment expenditure.

Table 7. Regression results of the influence of directors' postgraduate education characteristics on R&D investment in the IT industry.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
PMD	−4.80 **	−3.87 **					−3.91 **
	(−2.29)	(−2.07)					(−2.38)
PDD	0.92	0.42					0.33
	(0.70)	(0.32)					(0.25)
PEM			−1.02	−0.68			−1.02
			(−0.38)	(−0.27)			(−0.46)
PSE			0.13	−0.46			−0.01
			(0.04)	(−0.16)			(−0.00)
PC9					1.35	2.82	2.98
					(0.57)	(1.15)	(1.19)
POI					−1.67	0.05	1.26
					(−0.61)	(0.02)	(0.40)
ALR		−13.09 ***		−14.77 ***		−15.41 ***	−13.83 ***
		(−2.98)		(−3.17)		(−3.53)	(−3.65)
RDE		0.81		0.24		0.13	0.54
		(0.38)		(0.11)		(0.05)	(0.23)
Constant	13.84 ***	17.47 ***	10.97 ***	15.76 ***	10.52 ***	15.07 ***	17.55 ***
	(6.41)	(5.50)	(6.10)	(5.44)	(10.17)	(6.32)	(8.25)
N	148	148	148	148	148	148	148
r^2	0.06	0.14	0.00	0.11	0.00	0.11	0.15
F	2.97	3.53	0.12	3.18	0.44	4.67	3.12

Note: t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.4. Robustness Test

Endogeneity is a common plague in research involving corporate governance, firm policy, and performance [47]. There are many unobservable factors that may affect the hiring decision and R&D policy simultaneously, such as board directors' capacity, the firm culture, and so on. Coles and Li [48,49] identified that unobserved attributes of managers have a strong empirical association with riskier corporate policies, such as a higher R&D investment amount. Capacity of board directors can also lead to endogeneity problems. It is common that board directors' capacity is not only associated with their probability of attending postgraduate education, but also has a relationship with the firm's policy in terms of R&D investment. Thus, it will be biased to quantify the relationship between the director's postgraduate education characteristics and the firm's R&D investment without considering these variables. To address the endogeneity problem, Li suggested an extensive range of statistical methods and compared both the advantages and disadvantages of each method [50]. This paper chose to use control variables and the IV method to treat endogeneity issues, considering the nature and the availability of the data.

Corporate asset is directly associated with board members' capacity. Thus, we further added corporate asset into the statistic model as a control variable. Regression results reported in Table 8 suggest our estimation is robust after controlling additional firm attributes.

IV estimation is commonly used to mitigate the endogeneity problem caused by omitted variables. Using the IV approach needs to meet two conditions, i.e., IV must related to the endogenous explanatory variable and unrelated to the disturbing term. Previous engagement in R&D work is highly related with postgraduate education experience. The data from the Chinese Science and Technology Statistics Yearbook shows: 35.62% and 17.73% of people employed by R&D institutions are master's and doctoral degree holders [51]. Nonetheless, previous engagement in R&D work is usually not the requirement of being a board director. Additionally, we found the proportion of directors with master's degrees is significantly negatively related to a firm's R&D investment in the IT industry, which is different from the rest of the industries. Therefore, we used engagement in R&D work as the IV to test the robustness of our research results in the IT industry. IV 2SLS regression results are presented in Table 9. The first stage regression shows IV is highly related to the endogenous variable (p = 0.00). F statistics (F = 25.82) is greater than the normal threshold of 10, indicating our IV passes the weak IV test and has strong explanatory power to the endogenous variable. The second stage regression shows the coefficient of a directors' master's degree is still significantly negative. Therefore, the robustness of our regression results can be confirmed here.

Table 8. OLS regression results before and after adding firm asset.

	Before	**After**
PMD	0.14	0.18
	(0.53)	(0.67)
PDD	0.53 *	0.65 **
	(1.95)	(2.35)
PEM	0.00	0.07
	(0.00)	(0.19)
PSE	0.74	0.73
	(1.36)	(1.33)
PC9	0.01	−0.02
	(0.02)	(−0.06)
POI	−0.18	−0.13
	(−0.41)	(−0.30)
Firm asset		−0.47 ***
		(−4.67)
ALR	controlled	
RDE	controlled	
Industry	controlled	
Constant	2.88 ***	12.81 ***
	(4.15)	(6.28)
N	1374	1374
r^2	0.20	0.21
F	25.77	27.99

Note: t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 9. IV 2SLS regression results in the IT industry.

	First Stage	**Second Stage**	**OLS**
IFRD	0.62 ***		
	(5.08)		
PDD		1.49	0.33
		(0.51)	(0.25)
PMD	−0.13	−3.94 **	−3.91 **
	(−1.42)	(−2.11)	(−2.38)
PEM	0.26 **	−1.27	−1.02
	(2.08)	(−0.49)	(−0.46)
PSE	0.31	−0.24	−0.01
	(1.59)	(−0.09)	(−0.00)
PC9	−0.02	2.91	2.98
	(−0.11)	(1.08)	(1.19)
POI	0.15	1.00	1.26
	(0.77)	(0.41)	(0.40)

Table 9. *Cont.*

	First Stage	Second Stage	OLS
ALR	−0.18	−13.43 ***	−13.83 ***
	(−0.86)	(−3.08)	(−3.65)
RDE	−0.83 ***	0.58	0.54
	(−4.64)	(0.26)	(0.23)
Constant	0.33 ***	17.05 ***	17.55 ***
	(2.80)	(4.55)	(8.25)
N	148	148	148
Partial R^2	0.14		
F	25.82		

Note: t statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5. Discussion and Conclusion

Based on a sample of 1374 listed companies in China, this study analyzed the influence of directors' postgraduate education characteristics on R&D investment.

First, the R&D investment of China's listed companies needs further improvement and its distribution among different industries is highly uneven. The average proportion of a Chinese firm's R&D expenditure was 5.10% in 2017, which indicates a considerable R&D gap between China and the United States since the average R&D spending of American firms reached 14.5% from 1995 to 2015 [52]. Enterprise is the main driving force of a national innovation system. With the intention of building an innovative country, corporations should be encouraged to increase their R&D investment. When they are broken down to different industries, listed companies could be classified into four tiers, where IT industry was in the first tier, with R&D investment exceeding 10%. The second tier covered industrial (4.74$) and culture, education, and sports (4.32%). The next tier included agriculture, forestry, animal husbandry, and fishery (2.73%), public utilities (1.88%), and financial and real estate industry (1.69%). Commercial industry was classified into the fourth tier since its R&D expenditure was less than 1% (0.92%).

Second, the proportion of doctorates contributes significantly to the amount of R&D investment in firms, with the corporate asset-liability ratio, industry, and director's working experience being controlled. This finding helps to confirm the hypothesis that highly-educated directors are likely to increase the firm's R&D investment. As Wally and Baum noted, higher levels of education usually means greater cognitive ability [53], which allows for higher ambiguity toleration [36], better understanding of new ideas [37], more creative solutions to tackle complicated situations [54], all of which pave the way to increasing R&D investment. In respect to discipline background, science and engineering education experience may equip directors with innovation management knowledge and skills so that they gain more confidence to invest more on R&D activities [55]. But the graduation institution does not seem to have impact on directors' decision towards R&D investment. On one hand, this finding confirmed the important role of doctoral education in promoting a firm's R&D investment. On the other hand, the 'Top End Effect' shall not be excessively emphasized, and overseas returners may not bring in more R&D investment. The influence from the non-elite postgraduate education institutions are essential to the improvement of a firm's R&D investment as well.

Third, the influence of directors' postgraduate education characteristics on their firm's R&D investment generally occurs in the second industry. The higher the percentage of directors with postgraduate education degrees is, the more R&D investment will be. This is consistent with previous research conclusions based on the data from China's manufacturing industry [56]. Compared with other industries, the percentage of directors with master's degrees in industrial companies is relatively lower and has space for improvement. Therefore, enhancing the postgraduate education level for directors in industrial enterprises, especially increasing the percentage of directors with master's degrees on the board, may be one of the strategies to enlarge R&D investment for this industry.

Fourth, the high proportion of directors with master's degrees in the IT industry prevents corporate R&D investment. After employing the IV approach, the result is still robust. To find out the possible explanation, we checked the original data of the IT company with the lowest R&D investment (code = 300226). Results show it only invested 0.06% of total sales in R&D activities and its asset-liability ratio was up to 78%. As for its board configuration, all the directors are master's degree holders and majored in economics and management. This typical case indicates some IT companies tend to develop through raising capital instead of R&D innovation. Descriptive statistics reveal that nearly half (48%) of directors in this industry hold master's degrees, whereas the percentage of doctorate holders is only 24 percent. In terms of discipline background, 42% of directors majored in economics and management and only 20% majored in science and engineering. This may explain the negative coefficient between the percentage of master's degree holders and R&D investment in the IT industry.

6. Implication and Limitation

To summarize, this paper contributes to related research both theoretically and practically. In term of theoretical contribution, our findings extend the streams of literature concerning innovation management theory, upper echelon theory, and human capital theory by examining how the firm's R&D investment is affected by postgraduate education experience of directors, such as their education level, discipline background, and graduation institution. In contrast to prior innovation management research highlighting external determinants of corporate R&D innovation, our research finds the higher the percentage of directors with doctoral degrees, the more investment in R&D activities. This provides empirical evidence that internal factors from the board of directors also play an important role in R&D activities. In line with the research from the perspective upper echelon theory, this paper pays attention to a director's individual characteristics as well, especially educational characteristics. Our research findings indicate the association between a director's postgraduate education characteristics and a firm's R&D investment varies in different industry environments. In the second industry, which mainly consists of industrial companies, the higher proportion of postgraduate education degree holders as directors, the more expenditure in R&D activities. However, this correlation is not statistically significant in the third industry, which involves commercial, financial and real estate, public utilities, culture, education, sports, and IT companies. Through the lens of the human capital theory, there is economic value embedded in postgraduate education, which is justified in this paper in respect to R&D investment. In addition to the positive impact of human capital on economic growth and R&D innovation that has been studied thoroughly, our contribution lies in unpacking the complexity in reality due to certain attributes of both board directors and corporate developing strategies. Findings from IT companies confirm that, if a capital-driven strategy is adopted, directors with master's degrees and an economics and management background tend to reduce R&D investment. In term of practical contribution, our research findings lead to several prominent implications for enhancing the whole R&D investment of China's listed companies. Enterprises should realize the correlations between directors' postgraduate education characteristics and R&D investment, and then adopt targeting innovative strategies through board staffing and configuring. For the achievement of sustainable innovation of a state, national policy should also encourage universities to increase the availability of innovation and entrepreneurship education in the curricula system of postgraduate education.

Limitations of this paper and further research directions mainly lie in the following two aspects. First, R&D activities are highly risky and demand long-term investment [57]. Due to the fact that a firm's R&D investment has path-dependent inertia to some extent, tracking and analyzing synchronic rules of an enterprise's R&D investment will be the next research emphases. What's more, other factors like firm culture and technical advancement may also affect R&D investment and board hiring decisions. Limited by the availability of data in the CSMAR database, these factors are not considered in this paper. Future research may collect additional companies, and also extra variables to better model their contributions to R&D investment.

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Tensions in the Sustainability of Higher Education—The Case of Finnish Universities

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Abstract: Universities are increasingly engaged in marketization and are also expected to transform into more sustainable institutions and be change-agents pushing forward the movement of sustainable development. This article introduces an analytical framework originated by Hahn et al. (2015) for understanding tensions concerning corporate sustainability to the context of the Finnish university system in order to answer the following questions: What are the tensions relating to Finnish universities' social and economic sustainability, and what strategies might universities use to cope with these tensions? Through analyzing interviews with university managers and officials from the Ministry of Education and Culture in Finland, we find that Hahn et al.'s framework is generally applicable in analyzing tensions of sustainability in universities, and we identify six tensions relating to the sustainability of Finnish universities. The tensions are related to (1) academic leadership and management legitimacy, (2) regional political tensions and university profiling, (3) political power over the university system, (4) changing academic work and profession, (5) academic autonomy and the role of the state, and (6) the future role of the university institution. Moreover, the article discusses issues regarding how to adapt the framework of corporate sustainability to the context of higher education.

Keywords: sustainable universities; corporate sustainability; sustainability; tensions; integrative framework; Finnish universities

1. Introduction

In the book *A Larger Sense of Purpose: Higher Education and Society*, Shapiro [1] claims that universities have two roles: one is to serve the existing society, and the other is to challenge society to shape a better future. Today, the planetary crisis and sustainable development movement have raised new demands for higher education [2,3]. The 17 sustainable development goals (SDGs) adopted by the United Nations (UN) in the 2030 Agenda for Sustainable Development [4] underline a set of challenges paramount for universities to address [5]. The need for redefining a social contract between higher education and society [6], which was previously driven by mixed logics of being a social institution and being an industry institution [7], can now be argued to be driven by an additional force—the sustainable development movement, which champions the emerging concept of the "responsible university" [8].

The discussion regarding sustainable development and organizational change has gained momentum increasingly in higher education as well as in the corporate context [9]. This implies that universities have the same responsibility as any other organization to forward SDGs. In addition, special hopes are targeted at universities by different global institutions, e.g., the UN, which sees universities' roles as strategic knowledge producers and educators of future generations [5] (p. 31).

The scholarly discussion regarding sustainable development and organizational change and practices has been active in the field of business and management studies [9]. One can argue that the theories in the field of management studies regarding sustainability are more refined than in the field of higher education studies. In the research field of corporate sustainability, the win-win paradigm of perceiving sustainability as a profitable business for companies restricts sustainability solutions to conflict-free options with little ambition to fundamentally change core business practices for the sake of sustainable development [10] (p. 219). One of the prominent theories in the field is the integrative framework by Hahn et al. [11], which illustrates tensions related to sustainability in an organizational corporate context. The tensions [10] occur when an organization's objectives are in conflict regarding the three dimensions of sustainable development, namely ecological, social, and economic [12]. The framework by Hahn et al. [11] aims to illustrate these tensions and help companies see beyond the usual sustainability solutions aligned with the win-win paradigm.

The perspective on tensions is especially useful for understanding universities, which are increasingly operating in a hybrid context with contesting institutional logics [13]. Universities are organizations with huge expectations regarding their own organizational transformation [14] and their role in the global transformation toward sustainability [5]. While being loaded with expectations, it is crucial for universities to identify their tensions related to sustainability in order to contribute to their inner change processes as well as to the global change toward sustainable development, where they have a role as an abovementioned change-agent.

Several studies regarding the sustainable development of universities have been conducted in the field of higher education. Sustainability-oriented curricula and campus greening, i.e., minimizing of an organization's ecological footprint and societal sustainability agendas, are found to be areas in which universities should be leading as an example [14,15]. However, less attention has been given to the economic and social sustainability dimensions [16]. Also, there are as yet no appropriate frameworks for conceptualizing universities' organizational tensions regarding sustainable development in the field of higher education studies. That is why corporate sustainability, and especially the integrative framework [11], is relevant for introduction to the field of higher education studies.

One rare example of applying the integrative framework in the higher education context is the study by Sehnem et al. [17]. It analyses tensions of sustainability regarding establishing a new university campus of Unisul Sustentável–Pedra Branca in a sustainable neighborhood, with the Cidade Universitária Pedra Branca campus forming a conceptual framework using corporate sustainability theories from multiple authors.

The integrative framework [11] has not been fully introduced and adjusted to the higher education context. To fill this gap, we answer the following questions: What are the tensions relating to Finnish universities' social and economic sustainability, and what strategies might universities use to cope with these tensions? To approach the question, we will adjust the prominent framework by Hahn et al. [11] into the field of higher education. The modified framework will be tested in analyzing tensions related to Finnish universities' social and economic sustainability.

Finland has a dual model higher education system consisting of 13 universities and 23 universities of applied sciences [18]. Higher education policy has been a field of fierce political battles after Finnish universities were tied strongly to the state as part of social policy from 1960 onward [19,20]. The most significant and recent development in higher education policy is the Universities Act [21] law reform enacted in 2009. The new law enhanced universities' institutional autonomy, although "within a framework of greater accountability" [8] (p. 19) causing, strengthening, and also weakening several tensions in the Finnish higher education system [22]. Thus, the post-law reform Finland offers a fruitful context for testing the integrative framework by Hahn et al. [11], especially regarding social and economic sustainability.

The structure of the article follows. First, the analytical framework—the integrative framework by Hahn et al. [11]—is introduced. Then, the research methods of the study are explained, as well as the study itself. The article reviews the social and economic tensions related to Finnish universities' sustainable development and suggests strategies for coping with the tensions, after which it reflects upon the future application of the framework in the discussion section. Finally, the article concludes by answering the research question in the last section.

2. Analytical Framework: The Integrative Framework by Hahn et al.

It has been widely acknowledged in higher education literature that universities are increasingly confronting various tensions at both internal and external levels [7,22,23]. Higher education studies have also suggested various conceptual frameworks to understand both tensions and approaches to reconciling these tensions. For instance, these frameworks are included in studies on the dynamics of universities [13] and international joint education provisions [24], applying institutional logics [25], research on higher education institutions' missions [25], and applying the concept of academic drift [26]. However, as sustainability is entering the central agenda of higher education policy and university management, there is little research on tensions in universities from the perspective of sustainable development. Against such a challenge, we will develop an analytical framework for understanding tensions in sustainability and strategies of coping with the tensions in the university context, based on the conceptualization of corporate sustainability by Hahn, Pinkse, Preuss, and Figge [11].

Although the term "corporate sustainability" has been widely used, there is still no consensus on the definition of the concept; rather, common interpretation is built from the Brundtlandt Report [27] as "meeting the needs of a firm's direct and indirect stakeholders without compromising its ability to meet the needs of future stakeholders as well" [28] (p. 131). The discourse of corporate sustainability has focused more on the win-win paradigm and instrumental logics, where economic, environmental, and social sustainability aspects can be achieved simultaneously [11]. However, Hahn et al. [10] argue that tensions between these three dimensions are the rule rather than the exception, taking into account the multifaceted and complex nature of corporate sustainability. Hahn et al. [11] also argue that, following such a proposition, they develop an analytical framework for identifying tensions and approaches to managing them in a business setting.

The theoretical backbone of the framework is in the literature discussing strategic contradictions, tensions, and paradoxes [11,29–32]. As a paradox in this context, Hahn et al. refer to a situation in which oppositional elements co-exist [33] and in which individually accepted elements are inconsistent or incompatible together [34] (p. 563). The co-existing oppositional/conflicting elements are understood as two poles in a tension. Hahn et al. [11] argue that the ability of management to simultaneously pursue conflicting sustainability aspects is crucial when striving for corporate sustainability. Hahn et al.'s [11] framework is used to analyze two issues: what the primary tensions are (including oppositional poles in achieving sustainability) and what strategies are used to cope with the tensions. When dealing with the issues, Hahn et al.'s framework contemplates tensions that derive from the following aspects: (1) different understandings of the three dimensions of sustainability—environmental, social, and economic—across individual, organizational, and systemic levels; (2) different views on the change processes needed in order to become more sustainable; and (3) different views on the relevant temporal and spatial context of tensions illustrated in Figure 1 [11].

Regarding the first aspect, corporate sustainability is a multi-level concept [30], and thus the friction between different levels is one of the sources of tensions [11] (p. 302). The environmental, social, and economic dimensions of corporate sustainability have different connotations at different individual, organizational, and systemic levels of analysis. For example, tensions between organizational and systemic levels may arise if the organization's sustainability initiatives are not sufficient to address sustainability issues [11].

As an example of the occurrence of a sustainability tension regarding the second aspect, change could cause a disagreement between organizations in the transition toward renewable energy. Even though the technology might be developed sufficiently, the industry resists the change due to existing business models and alliances. Different kinds of vested interests incentivize organizations to act with different urgency levels toward sustainable development. [11,35].

Regarding the third aspect, contextual tensions stem from spatial and temporal elements of the context in which the transition toward sustainability takes place [11,29,30]. By the temporal element, Hahn et al. [11] refer to intergenerational equity for future generations. For example, if organizations' strategies overvalue short-term outcomes at the expense of long-term goals on certain other aspects—such as short-term financial performance versus long-term social performance—we are discussing a tension arising from the temporal context [11] (p. 303). The spatial element refers to intragenerational equity [11,36]. Different regions are at different development levels. An example of a tension arising from the spatial context could be a case in which a company operates in a developing country with different environmental or social standards [11]. The three perspectives provide a useful lens for identifying tensions and poles of paradoxes in achieving sustainability.

After the tensions are identified and understood profoundly, Hahn et al. [11] suggest three strategies for managing them by drawing on the insights from the literature on paradoxes in the field of management and organization theories. According to Poole and Van De Ven, paradoxes can be managed through opposition, spatial or temporal separation, or synthesis [11,29], where opposition represents an acceptance strategy and spatial and temporal, in turn, resolution strategies [11,29]. These three categories are the ones that Hahn et al. [11] suggest as the basis for the approach to managing tensions related to sustainability.

From these three approaches, the first type—acceptance strategy—refers to a situation in which decision makers differentiate the opposing two poles of a paradox, accept the resulting tensions, and maintain the paradox of seeking ways to live with it [11,32]. Compromise has not been sought; instead, the two poles of the contradiction are pursued simultaneously [11,33,37]. Improvisation is a characteristic of the opposition strategies coming from the everyday practice of the managers trying to "attend to both opposing domains of a paradox simultaneously while keeping the two poles apart" [11] (p. 300).

The other two strategies, resolution strategies, are used by managers to resolve a paradox "by spelling out the nature of the tensions between contrary positions" [11,29] (p. 300). Resolution implies "finding a means of meeting competing demands or considering divergent ideas simultaneously," instead of eliminating the tensions [11,29] (p. 300). Separation strategy means separating the two poles of the paradox spatially or temporally [11,29]. Spatial separation positions the poles on different levels, such as individual or societal, or different physical or social locations, whereas temporal separation divides the different poles into different points in time [11] (pp. 300–301). Synthesis strategy, in turn, refers to linking the opposing poles of a paradox together by a new perspective or element. Even though the mediating, overarching logic of combining the poles does not delete the paradox, it "offers a novel frame that can hold both opposing poles" [11] (p. 301).

As highlighted in the beginning of this section, tensions are a familiar topic in the higher education literature, and thus the integrative framework by Hahn et al. [11], contributing to the topic from a sustainability point of view, is relevant and interesting. Next, we will apply the integrative framework in the context of Finnish universities and test its validity in the higher education context, particularly in the case of Finland.

3. Research Methods

When investigating tensions in Finnish universities, we choose the method of phenomenology, as our research aims to increase general understanding of the phenomenon of tensions related to Finnish universities' sustainability. Since sustainability in the university context is a rather new phenomenon, phenomenology, with its exploration of meanings of new phenomena [38], was justified as the choice of methodology. Phenomenology focuses on peoples' experiences, perceptions of reality, and the meaning of those two [39]. The goal of the study was to understand interviewees' realities, construct organizational realities based on the similarities of the individual perceptions, and form a systemic view of the Finnish university system by comparing the individual and organizational perspectives to each other.

We used semi-structured interviews as a method for collecting data. The study had 11 interviewees, including:

- Four members of university management from a Finnish capital region university—three Vice-rectors and a Dean;
- Four members of university management from a Finnish northern region university—one Rector and three Vice-rectors;
- Three senior officials from the Finnish Ministry of Education and Culture working with higher education and science policy.

The 11 interviews formed an appropriate sample, since the interview data reached a saturation point in the end of the analysis, and the same themes were repeated throughout the interview data.

Interviews were designed to ask about the tensions but left room for reinterpretation of the tensions. The interview was constructed so that it proceeded from individual value-level questions regarding interviewees' jobs, personal values, and organizational values to four question sub-sets regarding personnel and management, research and education, finance and administration, and the role of universities. All interviews ended with a final reflection, where the interviewee had the chance to raise issues not mentioned in the interview or comment on the interview process.

The study followed Heideggerian Smith's interpretive phenomenological analysis (IPA), where the focus is on how the interviewees make sense of their personal and social world and the meanings of these experiences [40] (p. 126). According to Merleau-Ponty [41] (p. vii), phenomenology is "the study of essence" focusing on the essential meaning of phenomena [42] (p. 189). The study aimed to understand interviewees' individual experiences and perceptions as well as to find similarities and differences between the three organizations, in this way getting to the essence of the tensions surrounding social and economic sustainability in the Finnish university system. Interviews were recorded, transcribed, and analyzed throughout the interview process, and the transcripts were analyzed using NVivo qualitative analysis software. Field notes were also used to mark down possible notable aspects and thoughts evoked by the interviews. The analysis followed IPA's [40] (p. 126) typical four stages, where first the transcript is read and analyzed and themes developed to capture the essence of the interviewees' experience. Then, the themes were analyzed and formed into master themes. Third, transcripts were analyzed with the master themes, and finally, the analytic interpretation of the data is presented. The analysis focused more on what was said than how it was said, still taking into account the characteristic interactions and the interview experiences, especially if they were in contradiction with the interview quotes.

Regarding the limitations, in any qualitative research method, there are intrinsic limitations, given the biased views of researchers. In our case, since we both are working in a Finnish university, there is a risk that, when interpretating the data, we might use our experience and presumptions as a filter. To be aware of such a risk, the data was mainly analyzed by the author, who is new to the university working environment, thus maximizing objective interpretation.

The tensions were analyzed in three categories—weak, somewhat significant, and significant. Tensions were categorized as weak if only one interviewee mentioned the tension. Somewhat significant tensions were categorized if two interviewees mentioned the tension. Significant tensions were categorized if three or more interviewees mentioned the tension. The categorization in detail can be seen in Appendix A.

4. Tensions Related to Finnish Universities' Social and Economic Sustainability

When identifying tensions around sustainability, we focus on the management level of the Finnish university system and particularly on its social and economic sustainability, because the most topical discussion in the field of higher education studies focuses on social and economic tensions—e.g., autonomy of universities [8,39]—and global competition among universities and its consequences [40,43].

Social sustainability was defined according to Magis and Shinn [44] (p. 16) as constituting four principles: human well-being, equity, democratic government, and democratic civil society. Economic sustainability was defined, in alignment with Repetto [45] (p. 10), as maintaining the economic systems in a state that enables our generation to live on the planet, maintaining and improving the resources for future generations to live at least equally well or even better.

In Finland, the Universities Act law reform professionalized university management from 2009 onward, and tensions arose from, for example, the increased distance between the university community and management [22] and the structural development measures incentivized by public funding [46] (pp. 15–17). Although universities gained more budgetary freedom, the Ministry of Education remained in the steering position of the university system [42]. With management issues being examined and the study being explorative in applying a new analytical framework to the field of higher education studies, its focus was guided to the management level of the Finnish university system.

Our research did not focus on the environmental dimension of the integrative framework, since the literature from the field of higher education studies from which the initial tensions were drawn focused so strongly on tensions related to social and economic dimensions. Since well-functioning universities are crucial to the paradigm shift toward more sustainable ways of living, we saw the social and economic tensions as the first thing to explore in our study, which can later be extended to be more holistic.

Altogether, six tensions were detected between the organizational level of the university leaders and the systemic level of the Ministry of Education and Culture. The tensions were (1) academic leadership and management legitimacy, (2) regional political tensions and university profiling, (3) political power over the university system, (4) changing academic work and profession, (5) academic autonomy and the role of the state, and (6) the future role of the university institution. These six tensions' poles and the literature they are based on can be seen in Table 1. Four tensions, excepting numbers 3 and 6 (which relate to change), occur between the organizational and systemic levels, in between objectives of social and economic sustainability.

The first tension, academic leadership and management legitimacy, refers to the increased distance between the academic community and university management [22,43,46], which occurred after the Universities Act reform. Poles of the tension are economic sustainability objectives; striving for effective and centralized management versus social sustainability objectives; collegial, democratic academic management; and good social cohesion of the community. The tension was considered weak by the majority of the interviewees. Still, it is noteworthy, since this majority was the university leaders, whereas two out of three among the ministry officials detected this tension.

The second tension, regional political tensions and university profiling, refers to the tensions that occur due to profiling and structural development measures, which commenced after the 2009 law reform [22]. Competition for research funding is seen to lead to tensions inside academic communities [21,47], and this study supports it. In this tension, the social sustainability pole represents regional resiliency, and it is opposed to the economic sustainability pole: an effective and globally high-ranking national university system, which was the goal of the profiling measures.

The third tension, political power over the university system, was perceived as relevant by two out of four interviewees in the two universities and by one ministry official. In the literature, the political or policy drive for universities to respond to requirements from economic development versus universities' traditional social missions has been widely acknowledged [47]. In this tension, its poles are contextual and temporal. More precisely, the tension regards the duration of the political term in Finland. The rather short four-year period of a political term in the Finnish Parliament was perceived as a problem with respect to the long-termism of universities' nature. For instance, the results of the changes in university financing can be perceived only after years of development.

The fourth tension, changing academic work and profession, refers to the phenomenon of increasing the diversification of tasks of today's academic profession. Witchurch [48] describes this as the emergence of the "third space" in between academic and professional staff job descriptions. Also, sustainability-related competence can be inside the third space [49]. According to Aarrevaara and Hölttä [43], the increasing performance orientation in budgeting and other changes due to the 2009 law reform have affected the working environment of the university staff. Pinheiro et al. [18] mention that the current regulations do not necessarily guarantee fair working conditions for academics lacking sufficient resources for teaching and research or permanent work contracts. The social sustainability pole of the tension is the wellbeing of academics, which is in conflict with the economic sustainability objective; efficient universities excelling in global university rankings.

The fifth tension, academic autonomy and the role of the state, refers to the tension of the increased autonomy of universities, despite still being financially controlled by the state [18] (p. 7). There is no single definition for university autonomy [50], though it is one of the cornerstones of the university institution. According to Kohtamäki and Balbachevsky [50], the idea of autonomy has become to "serve the purposes of public policy" for national higher education policy purposes. In this tension, the poles are social sustainability objectives, autonomous universities, and academic freedom versus economic sustainability objectives.

Table 1. Tensions in Finnish universities between systemic and organizational levels.

Name of Tension	Identification of the Poles and Positioning in the Framework from the Interviews	Reflections in the Literature
1. Academic leadership and management legitimacy	Economic sustainability: effective, centralized management vs. Social sustainability: collegial, democratic academic management	Finnish higher education reform and its effects: Aarrevaara & Hölttä, 2008; Pinheiro et al., 2014 Assessment of the Universities Act 2009 Ministry of Education and Culture, 2016
2. Regional political tensions and university profiling	Social sustainability: regional resiliency vs. Economic sustainability: effective and excelling national university system	Discussion of the tensions in profiling in Finland: Pinheiro et al., 2014, Tirronen, 2015 Assessment of the Universities Act 2009 Ministry of Education and Culture, 2016
3. Political power over the university system	Temporal tension; Short-termism: the four-year period of members of the Finnish Parliament, political parties in power vs. Long-termism: universities' long-term nature regarding change and contributions	Political pressure from economic development versus universities' traditional social missions: Cai & Liu, 2020
4. Changing academic work and profession	Social sustainability: wellbeing of academics and ability to create high quality research vs. Economic sustainability: need for efficiency, increasing demands on researchers due to declining financial resources	Change of academic profession: Withchurch, 2012; Aarrevaara & Hölttä, 2008; Pinheiro et al., 2014
5. Academic autonomy and the role of the state	Social sustainability: autonomous universities and academic freedom vs. Economic sustainability: national need for efficient universities and research relevant for economic growth	Autonomy of Finnish universities: Kohtamäki & Balbachevsky, 2018; Pinheiro et al., 2014
6. The future role of the university institution	Change-related tension; future development of university institution vs. Future competitors overruling university institution	Development of knowledge-production modes 1 and 2, post-normal science: Gibbons et al., 1994; Ravetz, 1999 Development of university institution: Hammershøj, 2019

The sixth tension, the future role of the university institution, is a tension related to different perspectives on a change process, namely that within the university institution. The development of knowledge production from the traditional academic Mode 1 to a more participatory and interdisciplinary Mode 2 [51] and the discussion on post-normal science with an extended peer community [52] have been topics of discussion among the academic community for quite some time. Also, the development of university institutions has been discussed by many (e.g., by Hammershøj [53]) painting a perfect-storm scenario for universities, with the "AirBnb of higher education" threatening to take over if the employability needs of society are not acted upon. The poles of the tension are the change trajectories of future development of the university institution versus the future competitors overruling university institutions. Only one ministry official and two academic leaders from each institution detected the tension. Neither university leaders nor the ministry officials sensed many threats or competitors to university institutions' dominant position in the field of higher education.

5. Strategies for Managing Tensions in Sustainability

In this section, we reflect on the possible coping strategies for the six tensions detected in the study by using the integrative framework by Hahn et al. [11] and its examples of coping strategies. Although ambitious, this practice aims to illustrate possible coping strategies and simultaneously how the integrative framework can be utilized in the future. Even though our interview data did not comprise enough insights for suggesting certain coping strategies, we try to reflect the possible strategies for the six tensions between the organizational and systemic levels. We find that one tension can be coped with using different strategies (Table 2).

Table 2. Different coping strategies for the six social tensions regarding universities' social and economic sustainability.

Tensions	Acceptance Strategies	Resolution Strategies Separation Strategies	Synthesis Strategies
1. Academic leadership and management legitimacy	Simultaneously pursuing academic leadership and collegial decision-making—e.g., a management training for the academic leaders—while ensuring representation of the academic cimmunity in decision making	Separating the active members of the academic community to discuss and later present insights to the top management	A policy fostering members of the university being able to participate in the decision making
2. Regional political tensions and university profiling	Encouraging cooperation for regional resiliency and for efficient universities	Addressing regional resiliency and efficiency at different levels or groups in the ministry	Develop an institution to mitigate the tensions between regional resilience and national efficiency
3. Political power over the university system	An arena for dialogue for politicians and university leaders and policy-makers	Long-term orientation a core responsibility of the university's top management	Legislative change: university funding models impossible to change in one political term
4. Changing academic work and profession	Incrementally introduce new practices as part of researchers' job while taking care of wellbeing	Organizing workshops, trainings, and space and time for dialogue dealing with the stress and anxiety caused by the new pressures. Also organizing similar initiatives for discussing and ideating the future of the academic profession and learning new practical skills related to it	Engaging in an institutional change and actively shaping expectations optimistic about the future and toward the changing academic profession.
5. Academic autonomy and the role of the state	Cooperation between Ministry of Education and universities for solutions	Ministry and universities discuss autonomy issues first separately and then together	Establish an institution for discussing the tension of states' control on the university system
6. The future role of the university institution	Bringing together all the stakeholders to discuss the different futures of university and science	Different groups discussing different sub-topics of the future of university and science	Active and radical reflection of the future of university institution

For the first tension regarding academic leadership and management legitimacy, a possible acceptance strategy could be simultaneously pursuing academic leadership and collegial decision-making. For instance, the ministry level could organize professional top-management trainings for academic leaders, and in this way enhance modern, determined but participatory academic leadership. At the same time, the universities could involve the academic community in decision-making by ensuring representation of the staff in decision-making processes—for example, offering a seat in the board of the university. A possible separation strategy could be forming a group of active members of the university community to discuss separately and present their insights and ideas to the top management. A synthesis strategy, i.e., linking the opposing poles together, could be a new policy that would ensure that the members of the university community are being able to participate in decision making.

For the second tension, "regional political tensions and university profiling," an acceptance strategy could be encouraging cooperation between parties with opposing interests regarding both efficiency and regional resiliency to foster mutual understanding of the tension and work toward creative solutions. A separation strategy could be addressing regional resiliency and efficiency at different levels or groups in the ministry (which is still in the steering position of the university system) to ensure that the steering mechanisms enable both social and economic sustainability dimensions. A synthesis strategy could be to develop an institution to mitigate the tensions between regional resilience and national efficiency by, for instance, facilitating collaboration between universities and enhancing top-performing university units.

For the third tension, "political power over the university system," one kind of acceptance strategy could be ensuring that politicians and university leaders and policy-makers have an arena for dialogue. The dialogue would educate politicians about the characteristics of the university system and provide university leaders insights for acting in the political climate. Separation strategy, on the other hand, could separate the poles of the universities to make long-term orientation a core responsibility of the university top management and reward universities for reaching their own significant long-term goals. Our suggestion for a synthesis strategy could be a legislative change for ensuring that university funding models and policy frameworks cannot be changed significantly in one political term. This way, the state should also align long-term strategy regarding extensive budgetary changes, which would make funding more predictable for the universities.

For the fourth tension of changing academic work and profession, one potential acceptance strategy could be to incrementally and sustainably introduce new practices, while determinedly taking care of the coping of the academic staff. The poles could be separated with a separation strategy of organizing workshops, trainings, and space and time for dialogue dealing with the stress and anxiety caused by the new pressures. On the other hand, there could be similar initiatives for discussing and ideating the future of the academic profession and learning new practical skills related to it. We suggest for the synthesis strategy engaging in an institutional change and actively shaping expectations to be optimistic about the future and toward the changing academic profession.

For the fifth tension of academic freedom and autonomy, we suggest an acceptance strategy, where cooperation between the Ministry of Education and universities would be increased in order to foster mutual understanding of the tension and work toward creative solutions. A possible separation strategy could be to separate the poles of the tension (ministry and universities) to discuss their perspectives on autonomy issues, which would later be discussed together. An example of a synthesis strategy could be to establish a group or institution for mitigating the tension of academic autonomy and states' control of the university system. The institution should not be under the ministry of education and it should be as far away from the state control orbit as possible, which would be tricky.

For the sixth tension, the role of university institutions in the future, we suggest an acceptance strategy of bringing together all the stakeholders, including the small emerging actors, of academic research in Finland and the Finnish universities to discuss the future of university. For the separation strategy, we suggest separating the poles of the tensions, different groups discussing different topics regarding the future of university. This can be done inside universities or outside universities. For the synthesis strategy, we suggest that the universities and the Ministry of Education actively reflect the future of the university institution with genuinely different scenarios and carry out their own vision of the university institution in a future-oriented manner.

6. Discussion: How the Integrative Framework and Corporate Sustainability Can Be Used in the University Context

This section outlays the limitations of the study by contemplating what can be learned from the case of Finland, when applying the integrative framework in the future. Also, the differences and similarities regarding the university context in comparison to the corporate context are discussed along with suggestions for future research.

6.1. What Can Be Learned from the Finland Case Study?

One may rightly ask, what is the value of the integrative framework on the Finnish, or any, university system regarding sustainability, if all its dimensions are not taken into account simultaneously? In this case study of Finland, the decision to study only social and economic tensions is justified with the urgency and scale of the social and economic tensions. This decision, however, prevents perception of the holistic sustainability possibilities, where, like stated previously in the text, environmental sustainability is the driving force and crucial element—the motive for the study itself. The dimension of environmental sustainability should be included in the study, so that the results would be holistic and provide the analytical lens that saves managers from making decisions belonging to the instrumental logic paradigm [10]. On the other hand, this type of research design can work as a basis for further analysis, where the environmental dimension is then taken into account. It does have to be taken into account at some point, since that is the overall goal of the whole analysis.

Another aspect worth paying attention to is the question of how the tensions of sustainability are detected. In the case study, the six tensions were formed based on literature, which then formed the basis of the semi-structured interviews. This way, the interviewees were already somewhat limited with their answers. One can ponder what kind of tensions would have emerged more inductively from the minds of the university leaders and ministry officials without being primed with the themes of the six initial tensions. It is up for the researcher to decide in what manner to narrow the scope of the tensions depending on whether the objective of the study is to explore all the possible tensions, or to study tensions that are known beforehand to some extent.

Studying these tensions puts a lot of weight on the definitions of sustainability used by the researcher. As discussed [9], the definitions of sustainability are still in the development phase and researchers are responsible for providing clear explication as to why and how a tension is one of social, economic, or environmental sustainability. In the case of Finland, the link of the six tensions to social and economic sustainability exists, but can be more or less complicated to grasp, for example in the second tension. Regional political tensions and university profiling are defined as a tension of social sustainability because of a university institution’s role in building social cohesion and enabling sustainable development [5]. Another view of the tension could be spatial, since the question is also about regional versus centralized emphasis of the university system.

6.2. Strategies for Managing Tensions in Sustainability

Among the practical implications and societal values of the integrative framework [11] are the strategies for managing the tensions of sustainability. The opposition, spatial or temporal separation, and synthesis strategies [11] are built on the literature on paradoxes. The two poles form a paradox and are used as in Section 2, by opposition, separation, and synthesis to manage the tension.

The focus of the study is important when choosing what part of the integrative framework [11] is applied as an analytical lens. In the Finland case study, levels are used as the lens, almost omitting the dimensions of change and context. Depending on the focus of the study, the dimensions of context and change, or all three dimensions, might be suitable for application to a greater extent. The tensions of this study were explored in order to study what kinds of tensions of social and economic sustainability exist in the first place. The scope of the study was not targeted at any level, and thus the tensions are very broad, as are the suggested coping strategies. For the future application of the integrative framework, the narrower the scope, the better the results for forming coping strategies.

6.3. Suggestions for Future Research

Besides integrating the environmental dimensions to the analysis, there are other suggestions to be made based on the limitations of this study. First, as the primary purpose of study is to introduce Hahn et al.'s [11] analytical framework of tensions in corporate sustainability into the field of higher education studies, a relatively small number of interviews was chosen for empirical analysis. Thus, the empirical findings of the study need to be further verified and extended to a larger context in future studies.

Second, the study focused on the tensions between the organizational and systemic levels represented by the ministry officials and university managers. In future research, it would be interesting to expand the focus of the study to the individual and organizational level of universities. In addition to university managers, academics from different fields of research as well as administrators could be included in the group of interviewees to study the possible differences of perceptions regarding social, environmental, and economic sustainability.

7. Conclusions

The scholarly discussion regarding sustainable development and related organizational changes has been active and more refined in the field of business and management studies [9], compared to the field of higher education research. Although sustainability and sustainable development of universities has become a popular topic, less attention has been given to deep analyses of the economic and social dimensions of sustainability [16], and there are yet no appropriate frameworks for conceptualizing universities' organizational tensions regarding sustainable development. This paper has applied a prominent analytical framework on corporate sustainability by Hahn et al. [11] to the higher education context, and approved the usefulness of the framework in analyzing the tensions relating to Finnish universities' social and economic sustainability as well as strategies to be used to cope with these tensions. Specifically, the tensions found in this study are related to (1) academic leadership and management legitimacy, (2) regional political tensions and university profiling, (3) political power over the university system, (4) changing academic work and profession, (5) academic autonomy and the role of the state, and (6) the future role of the university institution. In addition, we explored the coping strategies for each tension in Section 5.

We suggest the following five issues to be considered when applying the integrative framework. First, one should take into consideration all three types of tensions—social, economic, and environmental—when striving for the holistic view on different potential strategic choices regarding sustainability, and one should not to be restricted by the instrumental view on sustainability. Second, the aspect of whether the goal of the research is to explore new tensions or study acknowledged tensions should be taken into account in the research design. Third and fourth, the definition of tension related to societal, environmental, and economic sustainability should be explicit, as should be the different poles of the tension. Finally, the dimensions of the integrative framework—change, context, and levels—can be applied by the researcher to the part suitable for the tensions at hand.

Although marketized and sharing similarities with corporations, universities are different kinds of organizations with different objectives, organizational structures, and purposes. This has to be taken into account in general when applying the integrative framework or other frameworks from the field of corporate sustainability to the university context. The level of resemblance to a corporation depends a lot upon the university being studied. How much of a quasi-business organization [54] does the university or universities in question resemble? Although universities are increasingly marketized [55], they do not function by the private market logic but are, especially in the Nordic countries, financed by the state [56]. A corporation's duty is to make a profit for its owners [55], while the university's duty in Finland is enacted in the law, comprised of research, education, and third mission tasks [21].

The integrative framework [11] from the field of corporate sustainability is a relevant framework for the higher education context, since universities have to change toward more sustainable organizational practices themselves. In addition, universities are expected to be active change-agents contributing to the sustainable development movement by educating the future workforce as well as producing relevant and crucial knowledge regarding the future of humanity [5]. This article was an initial step toward integrating corporate sustainability literature into the discussion of the sustainability of higher education institutions.

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Appendix A

Table A1. Perception of the tensions in each organization.

Tension	Ministry of Education and Culture Level of the Tension: * = Weak Tension, 1 Interviewee Mentioned ** = Somewhat Significant Tension, 2 Interviewees Mentioned *** = Significant Tension, 3 + Interviewees Mentioned	Northern University Level of the Tension: * = Weak Tension, 1 Interviewee Mentioned ** = Somewhat Significant Tension, 2 Interviewees Mentioned *** = Significant Tension, 3 + Interviewees Mentioned	Capital Region University Level of the Tension: * = Weak Tension, 1 Interviewee Mentioned ** = Somewhat Significant Tension, 2 Interviewees Mentioned *** = Significant Tension, 3 + Interviewees Mentioned
1. Academic leadership and management legitimacy	** Somewhat significant tension	* Weak tension	* Weak tension
2. Regional political tensions and university profiling	* Weak tension	*** Significant tension	** Somewhat significant tension
3. Political power over the university system	* Weak tension	** Somewhat significant tension	** Somewhat significant tension
4. Changing academic work and profession	* Weak tension	*** Significant tension	*** Significant tension
5. Academic autonomy and the role of the state	* Weak tension	*** Significant tension	** Somewhat significant tension
6. The future role of the university institution	* Weak tension	** Somewhat significant tension	** Somewhat significant tension

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Changing Times at Cuban Universities: Looking into the Transition towards a Social, Entrepreneurial and Innovative Organization

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Abstract: Since the 1990s, the socialist higher education system has faced several reforms oriented to satisfy social, economic, and technological demands. However, little is known about the transformation process of the socialist university system over the past two decades. This study provides a better understanding of the entrepreneurial and innovative transition of universities located in socialist economies. By adopting mixed theoretical approaches, we proposed a conceptual model to understand the social, the innovative, and the entrepreneurial transformation of socialist universities. We revised and tested this model in the context of Cuban universities by implementing a prospective case study approach. Our findings show insights about the transition towards a business model innovation within Cuban universities. The determinants have been state regulations, the closing of the complete cycle from teaching to the commercialization of results, and the creation of hybrid structures to manage knowledge. Consequently, the university is facing managerial challenges related to its ability to explore and exploit its activities to generate social, innovative and economic outcomes. Our results provide practical implications for the university managers and actors involved in the transformation process of Cuban universities.

Keywords: higher education system; social entrepreneurship; entrepreneurial universities; business model innovation; innovation ecosystem; socialist economies; Cuba

1. Introduction

During the last two decades, diverse university models have emerged into the new social and economic landscape [1,2]. Extant literature has provided insights about the entrepreneurial and innovative transformation pathways of universities [3–7]. Concretely, the transformation pathways have been associated with internal conditions like university governance/leadership, financial autonomy through diversified sources of funding [3], the organizational culture [4], and the university's resources and capabilities [6,7], as well as external conditions such as the influence of public policies on the configuration of the transit in a country [5] and the stakeholders' influence [6,7]. This accumulation of knowledge about innovative and entrepreneurial universities has legitimized the social, economic, and technological contributions in economies in places such as Australia, Europe, North America, and the United Kingdom [6–10]. However, the experience of entrepreneurial and innovative universities from developed economies is not necessarily applicable in the case of universities located in socialist or emerging economies [11]. By contrasting with developed economies, Cuba has particularities based on the construction and sustainability of socialism. The premise is the centralized allocation of resources and vertical orientation in the design of public policies. Although the socialism premise is maintained, its current open strategy demands new institutional conditions to transiting into new ownership forms, as well as the configuration of the pillars of an innovative entrepreneurship ecosystem (i.e., banking reforms, the Science/Technology regulatory frameworks, and the entrepreneurial mindset). At the university level, entrepreneurship is not allowed. It explains the misunderstanding of entrepreneurship in the academic context, as well as the inexistence of actions to foster graduate and academic entrepreneurship.

A few studies have provided insights into the innovative and entrepreneurial role of universities located in socialist economies [10,12–15], as well as proposing frameworks to understand the link of the university into the national innovation system [16,17]. These studies provide insights about a third mission that is understood as the extension of social university functions and the knowledge transfer to society. Moreover, anecdotal evidence has evidenced some insights into new business models, as well as some insights on the involvement of the productive sectors' competitiveness and social wellbeing [18]. However, little is known about how we may conceptually understand the social, entrepreneurial, and innovative transformation process of universities in socialist economies. Concretely, how have universities located in socialist economies have been transforming themselves into social, innovative, and entrepreneurial organizations? How have university managers transitioned into innovative business models? How have universities located in socialist economies been impacting on the regional innovation system? How effective have the pro-market state regulations been?

Inspired by the research opportunities, this paper provides a better understanding of the entrepreneurial and innovative transition of universities located in socialist economies. By adopting the theoretical bases of entrepreneurial universities [4,6], social entrepreneurship [19], and business model innovation literature [20,21], we propose a conceptual model to analyze the transition of socialist universities into a social, innovative, and entrepreneurial organization. By using the retrospective case study methodology [22,23], we explore the entrepreneurial and innovative identity of Cuban universities by its transition of traditional business models into new business model innovation. Our findings show insights about the multiple challenges, determinants and the transition of Cuban universities.

Our research setting is the Cuban university. According to the Cuban Constitution [24], the university has been a non-profit public organization with an economic dependency on public funding given their social goal: to provide free and high-quality education to Cubans. After the 1990s economic crisis, the Cuban State redefined the national policies and higher education legislation to reinforce the relationship between the university and the productive sector [25]. At this stage, technology and innovation were priorities for improving the socio-economic situation faced by the productive sector through enhancing its collaboration with universities. This action was oriented towards the generation of economic and social impacts via the university in pursuit of the country's growth [24]. Several incentives and intermediaries (i.e., the technology transfer offices) were implemented to enhance the generation, management, and commercialization of technology [18]. Afterwards, due to the need for updating the Cuban economic model in 2016, the Cuban State established new economic and social policies [25,26]. At the higher education level, Article 14 prioritized the link between organizations that developed productive activities and universities that guarantee their technological and innovative transformation [26] (p.8), and Article 22 prioritized the generation of qualified human capital accordingly to the needs of the new economic and social model [26] (p.10). Concretely, these articles guarantied the proactive role of universities into the country's social, cultural, and economic development.

After this introduction, the paper is structured as follows. The second section analyzes the theoretical foundations linking entrepreneurial universities and business innovation models. The third section describes the case study methodology adopted in this research. The fourth section presents the findings and discusses them considering previous studies. The paper concludes with the conclusions, implications, and research agenda.

2. Theoretical Foundations

2.1. Understanding the Entrepreneurial and Innovative Identity of Universities

Despite the lack of consensus, an entrepreneurial and innovative university is generally understood as a natural incubator that provides an adequate environment to support the entrepreneurial and innovative initiatives developed for the university community (i.e., students, academics, staff, alumni) [6–8,10]. The adequate environment has been configured by conditions that foster entrepreneurship and innovation [1]. Based on the accumulation of knowledge regarding this phenomenon, Table 1 summarizes the determinants, the inputs, and the outputs of universities with an entrepreneurial and innovative identity.

Table 1. Key elements behind the entrepreneurial and innovative identity of universities. Source: Authors.

Key Element		**Characteristics of Entrepreneurial and Innovative Universities**
Determinants	External	Public budget restrictions Spin-off/start-up normative Knowledge transfer regulations Labor market conditions
	Internal	University has created an adequate entrepreneurship and innovation ecosystem A strong relationship with agents involved in the regional innovation and entrepreneurship ecosystems
Inputs	Resources	Incentives and reward systems Mentors supporting entrepreneurship and innovations Technology and innovation resources
	Capabilities	Leadership Positioning in the radar Networks and alliances
Outputs	Teaching	Job seekers and entrepreneurs
	Research	Publications
	Transference	Patents, licenses, spin-offs
Business model		Multiple income streams Exploration/exploitation of entrepreneurial and innovative opportunities

Regarding the external conditions, Guerrero et al. [2] evidenced the role of universities as a key participant and contributor within the regional innovation systems. In this vein, by adopting the endogenous growth theory, Guerrero, Cunningham and Urbano [8] proposed a conceptual framework to understand the economic contribution of universities in society. Concretely, the universities' core activities have been associated with the economic production function. Consequently, teaching has been linked to the human capital factor; research has been related to knowledge capital; and transference has been related to technological and entrepreneurial capital [10]. Therefore, university managers should adapt to the university role based on the stakeholders' requirements in terms of qualified human capital, knowledge, and new technological advances [27].

Regarding the internal conditions, Clark [4] proposed the internal pathways for the entrepreneurial and innovative transition of universities. However, many of these pathways have evidenced in universities located in the context of advanced economies such as North American Universities [3], European Universities [6,7,11,27], and Asian universities [28–30]. Therefore, these pathways do not necessarily apply in the context of emerging or socialist economies. The plausible explanation is the existence of institutional voids, as well as the specific realities and needs demanded by these economies [9,11]. For instance, one of the most relevant pathways has been the diversified sources of funding motivated by the reduction of public resources [4]. Therefore, innovative and entrepreneurial universities should look for sustainable sources of funding [10]. In this vein, university managers should look for new alternatives to capture value from the university' resources and capabilities efficiently [31].

The main inputs and outputs of entrepreneurial and innovative universities are aligned to their core activities [6,8,10]. In this assumption, the entrepreneurial and innovative university should adapt its business model for responding to the new demands of the stakeholders and global context [21]. The main challenges are aligned with the organizational culture, the attitudes towards entrepreneurship and innovation, and the (in)formal relationships with stakeholders [2,28,32]. For instance, the transformation process has been motivated by the fostering of entrepreneurial initiatives through spin-offs/start-ups and technology-based ventures [10]; as well as innovative initiatives through the transference of knowledge or technologies to the productive sectors via licenses, patents, inventions, and intellectual property rights [1].

2.2. Understanding the Social, Entrepreneurial, and Innovative Identity of Universities

In socialist economies, the universities' missions are defined by the state demands and oriented towards achieving the demands of qualified human capital [15]. By adopting the social entrepreneurship approach, we assume that any organization enrolled within the socialist context is occupied with developing innovations to address complex societal, economic, or environmental challenges [33]. However, the universities' sustainability is conditioned by the "entrepreneurial" ability of these organizations to access or leverage means (financial, human, physical, and technological). Based on the accumulation of knowledge of this phenomenon, Table 2 shows the differences observed in the determinants, inputs, outputs, and business models with entrepreneurial and innovative universities described in the previous section.

Table 2. Key elements behind a social, entrepreneurial, and innovative identity of universities. Source: Authors.

Key Element		Universities within Socialist Economies	Differences between Entrepreneurial and Innovative Universities
Determinants	External	State regulations and demands Economic crises and social uncertainty	The misunderstanding of an entrepreneurial identity within a socialist society and disconnection with local agents
	Internal	Knowledge transfer infrastructures	The lack of favorable attitudes towards entrepreneurship and innovation given the misunderstanding of these terminologies
Inputs	Resources	Intellectual human capital but without motivation Technological resources	The lack of incentives towards entrepreneurship and innovation
	Capabilities	Specialized groups associated with the industry	The lack of entrepreneurial leadership that promotes these transformation process, as well as the disconnection with the productive sector
Outputs	Teaching	Job seekers	The lack of start-ups (graduate entrepreneurs)
	Research	Publications	
	Transference	Patents, licenses	Lack of spin-offs (academic entrepreneurs)
Business model		Dependency on state funds Delimited activities and resources	The sources of funding and the absence of innovative and entrepreneurial orientation

Regarding the determinants, the social identity of universities located in socialist economies is determined by the state. Therefore, the transformation towards an entrepreneurial and innovative organization should be determined by reforms in the higher education system and motivated by the socio-economic conditions [14]. Despite the state legitimization, the misunderstanding of what an entrepreneurial and innovative university means has represented the main obstacle for connecting universities with external agents [13]. In this vein, the social norms and culture condition the transformation of universities [9,11]. At the internal level, the existence of knowledge transfer infrastructures that support knowledge management is favorable to this transformation [2]. However, the lack of an entrepreneurial culture and favorable attitudes towards entrepreneurship represents another barrier in the transformation process [11]. It is explained by the lack of understanding of the university community about the meaning and significance of entrepreneurial initiatives [15].

Regarding the inputs and outcomes, the transformation process is also conditioned by the development or improvement of university capabilities [31]. The university leadership, staff, academics and faculty are the main actors in the implementation and the success of any university core activity. However, the socialist universities are characterized by a lack of incentives that foster the enrolment of the university community as well as a lack of leadership that promotes links with the productive sectors [15]. It implies an organizational culture characterized by focusing only on the achievement of the university's social purposes. Therefore, the university community should acquire skills and knowledge that are required to implement the business practices introduced in the new university's business models [34]. It will open a window towards understanding the creation of star-ups by graduate entrepreneurs or spin-offs by academic entrepreneurs [10]. The intervention of external agents should be an alternative for building a social, innovative, and entrepreneurial identity.

2.3. Understanding the Business Model Innovation of Socialist Universities

According to Zott and Amit [20] (p. 110), business model innovation is understood as the way in which an organization "does business" with its clients, partners and suppliers. In other words, it is a system of activities that are developed by the focal organization, and its partners carry out to meet the perceived technological needs in the market. In this vein, innovation business models refine the objectives, value propositions, and expected outcomes [35–37]. Consequently, the business model should be aligned to the organizational identity (i.e., social, entrepreneurial, and innovative).

At the university context, extant studies have evidenced that universities have applied business models such as a mechanism to position the contribution of their core activities into the regional competitiveness [38], to achieve sustainability [21,39], and create value according to the Oslo Manual [40]. Social entrepreneurship research has also evidenced the design of hybrid models based on the dual mission: social and entrepreneurial [19,36]. However, little is known about the configuration of university business model innovation in socialist economies that are characterized by a non-profit orientation.

Table 3 shows the main details of the accumulation of knowledge of business models in the university context. The business model innovation design implies the precise definition of the organizational objectives considering the stakeholders' needs and aligns them to the organizational strategies [41]. Then, it will be necessary to define the resources and capabilities needed to achieve the expected results without forgetting the relationships with external agents enrolled in the innovation ecosystem [39,42–44]. All elements are critical for implementing mechanisms that ensure the adaptation to the uncertain external conditions [44–46].

Table 3. Business model innovation applied in the university context. Source: Authors.

Authors	Business Model Innovation	Adaptation at the University Level
Mets [41]	The business model for commercializing R&D in the triple helix context	The university contributes to the intellectual capital The university optimizes the commercialization of research and new income stream Entrepreneurship is a critical component of the third mission
Gaus and Raith [39]	Value creation and knowledge transfer model	Knowledge transfer and entrepreneurship as part of the third university mission Business model innovation delight the university governance
Miller et al. [20]	Business model innovation under the stakeholder perspective	The business model is a system of combined university core activities Objectives and relationships are aligned to the business model innovation and its evolution
Abdelkafi, Hilbig and Laudien [42]	Business models of entrepreneurial universities in the area of vocational education	Key decisions and choices should take university managers Business model patterns that can be applicable to extend traditional business models and embark on an evolutionary path to satisfy the necessity of independently generating funds.
Armstrong [43]	Business model implications for North American universities	The influence of environmental conditions (institutional effectiveness and stability) Business model innovation as a tool for understanding and adapting to the environmental challenges
Posselt, Abdelkafi, Fischer, et al. [44]	Business model innovation	The definition of value proposition, business creation, communication, technology transfer within the university context

2.4. Proposed Conceptual Model

By assuming that business model innovation should be aligned to the identity of the organization, Figure 1 shows the proposed conceptual model for understanding the transition of socialist universities into social, innovative, and entrepreneurial organizations. Determined and legitimized by the State's demands, the universities in socialist contexts should align their social identity (provide qualified education and generate knowledge) with the innovative identity (technology transfer activities) and the entrepreneurial identity (commercialization of knowledge, technologies and innovations). Given the unique characteristics of socialist economies, the assimilation of the entrepreneurial culture may require the involvement of intermediaries (technology transfer offices, incubators) to facilitate the sensitization process and technology management [10,11]. By assimilating the aligned identity, universities will be able to configure the business model innovation activities that add value to the stakeholders [21,44].

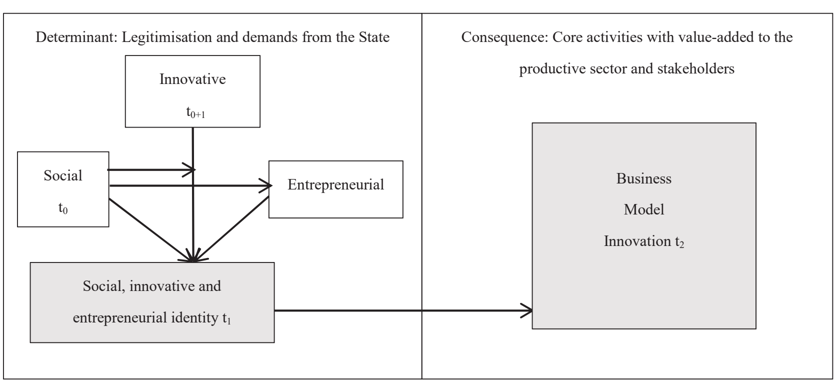

Figure 1. The proposed conceptual framework. Source: Authors.

3. Methodology

3.1. Retrospective Case Study Approach

Our research setting was at Cuban universities. By drawing on the nature of this research and previous university qualitative studies [7,11,16,17], this research was designed according to a retrospective case study perspective of the transition of Cuban universities into a social, innovative, and entrepreneurial organization. Although qualitative studies have several criticisms regarding convenience or biased sampling, the retrospective case study approach allows understanding events, facts, and activities that had already occurred and their results were known [22]. The transformation process of the Cuban universities has taken at least over the last two decades. Therefore, we believe that this methodological approach is the most appropriate to test our proposed model (Figure 1).

3.2. Data Collection and Data Analysis

The data collection process adopted the triangulation approach suggested by Yin [23]. This approach consists of combining diverse sources of information to gather data about the studied phenomenon. The primary sources of information were twenty semi-structured interviews with university actors (academics, university managers), intermediaries (head of incubators, technology transfer offices, development agencies), and productive sector representatives (organizations developing technological projects in collaboration with the university). To ensure the representativeness participants, the main criterion of selection was their involvement in this transition process of Cuban universities during the last twenty years. Changes in Cuban universities are assumed to be based on government regulations and standards and are generally homogeneous.

Table 4 summarizes the interviewees' profile. University actors (UA) are six academics and five managers involved in the most representative universities with the recognition of excellence in Cuba. The universities are the Universidad de La Habana (the longest established and most internationally visible university—three hundred years old), the Universidad Central Martha Abreu de las Villas (the third university inaugurated in the country—sixty-eight years old), the Universidad de Oriente (the second-highest public institution in the country—seventy years old), and the Universidad de las Ciencias Informáticas (one of the consolidated technological universities—eighteen years old). The six academics have the highest categories established by the Cuban Higher Education System: the senior researcher category and the senior lecture category. They have been involved in the development of teaching and research activities. The five university managers have acquired a strong experience in the direction of teaching (vice-rectors and head of teaching departments) and science/technology (vice-rectors, head of R&D center) core activities during their involvement in different universities. The intermediaries (I) have a vast experience in the incubation of university projects and the technology transfer of academic/professional services to the productive sectors and society. Concretely, the participants are the heads of one incubator, three technology transfer offices, and two development agencies. The representatives of product sectors are linked to three priority sectors in Cuba: the Biotechnology Industry, the Software Industry and the Science, Technology and Environment Ministry. These organizations have collaborated with universities for developing technological initiatives.

Table 4. Interviewees' profile. Source: Authors.

Profile	Number of Participants	Years of Experience (Average)	Age (Average)
UA: University actors	Six academics	47 years	70 years
	Five university managers	25 years	54 years
I: Intermediaries	Head of incubators	27 years	43 years
	Heads of three technology transfer offices	30 years	53 years
	Head of two development agencies	33 years	60 years
P: Productive sector representatives	Three representatives of organizations developing technological projects in collaboration with the university	31 years	69 years

The fieldwork was developed for nine months (May 2019–February 2020). Each interview had a duration of 1 to 2 h, as well as with the possibility of re-contacting to clarify doubts or gaps. Concerning the data analysis, all interviews were recorded and transcribed. The transcriptions were complemented using secondary data from official documents and annual reports. Afterwards, the data were coded and analyzed according to the patterns and concepts identified in our proposed model (see Appendix A).

4. Findings

4.1. The Transition into Business Model Innovation

The identity of Cuban universities has been identified through the evolution of its business model. Three decades ago, the business model of Cuban universities was defined by the academic, research and university extension activities (Table 5). According to the interviews, the State acted as the primary client and the sole funder in this traditional business model. The State maintained their investment during this period for ensuring the quality of the education [18]. Therefore, given the financial dependency, Cuban universities' value propositions were defined by the State demands: generate qualified human capital, cover the labor market needs, create cutting edge knowledge, and diversification of research fields, among others. In this vein, the most relevant clients were employers, enterprises, and research centers.

Since the 1990s, the Cuban university business model transitioned towards new sources of funding (revenue streams) by the introduction of activities related to the commercialization of innovation and technology transfer (new added value) via intermediary structures (channels). According to university actors, "as the funding amount destined to the university decreased, universities were oriented to identify potential services to commercialize, as well as to evaluate a new type of relationships with the productive sector" (Interview UA11). However, these new activities were not conceptually understood as the so-called third mission of American and European universities. According to the interviews, the transition of universities was based on trial and error with the involvement of intermediaries for knowledge innovation management. The State increased its investment in higher education and infrastructures but without clear evidence about the return of this investment [18].

Table 5. The traditional business model of Cuban universities (until 1993). Source: Authors.

Associations with	Activities	Added Value	Relationships	Clients
- State - Higher Education Ministry - Embassies - Universities	- Teaching - Research - Extension **Resources and capabilities** - Students - Professors - Researchers - External agents - Infrastructures - Budget	- Qualified human capital - Diverse teaching programs oriented to cover the labor market needs - Cutting edge knowledge by diversifying research fields	- Student - Tutors - Secretariat **Channels** - Working placement - Editorials and scientific agencies - Events and socio-cultural projects	- State (as an employer) - Employers - Enterprises - Universities - Society - Cuban students - Foreign students - Research community (foundations, centers)

Costs	Income
- Salaries - Costs for infrastructure for teaching and research - Costs for infrastructure and administration - Other costs	Non-monetary - University recognition/prestige - Scientific publications, patents, copyrights Monetary - Government budget - Scholarship funds - Enrolment

In the Cuban university system, the new mission was conceived as the university extension towards the development of social actions. It implies entrepreneurial and innovative orientations to support the transformation of productive actors towards sustainable development. In this vein, the Cuban university became the provider of technological solutions to the productive sectors' needs (i.e., scientific events, professional services, technological applications, and property rights for using patents and tests). According to the representatives of productive sectors, "the 1990s scenario made it possible to exploit the university's capabilities and to expand the university's activities towards new professional services like consultancy" (Interview P2). The premise was the production, transfer and appropriation of innovations that democratically satisfy the social aspirations of the population and promote the economic development (Table 6).

Table 6. The new elements of the business model of Cuban universities (since 1993). Source: Authors.

Associations with +	**Activities** +	**Added Value** +	**Relationships** +	**Clients** +
- Productive sector - Ministries - Research institutions and centers - Foreign universities and associations	- Product development - Technology transfer - Post-graduate programs	- Post-graduate programs - Technological and innovative advances - Specialized services	- R&D collaboration and networks - Research agreements, contracts	- Government - Universities' (Cuban and foreign) Enterprises, family organizations - Ministries - Research institutions and centers
	Resources +		**Channels** +	
	- University community (staff, academics, professors) - R&D specialists and capabilities - Entrepreneurial leadership		- Innovative methodologies within courses - Post-graduate programs	
Costs +		**Income** +		
- Knowledge transfer management - R&D personnel - R&D infrastructure - Post-graduate programs		- Enrolment and tuition from foreign students - Scientific and technological events (fees) - Specialized services (fees) - R&D collaborations		

In the last fifteen years, universities experienced several organizational/management models for developing productive projects, science and technology parks, scientific poles, project incubators, and production centers. These initiatives have been developed via agreements with non-profit nationals or contracts with national and international companies. The establishment of university-industry relationships allowed the production and commercialization of technological solutions/products oriented towards the domestic and international markets.

4.2. The Determinants of a Social, Innovative and Entrepreneurial Identity

We identify three essential elements that enabled the effectiveness of the transition process of universities into social, innovative and entrepreneurial organizations. The first element is the state regulation that allows the legitimization of the innovative identity (the 1993 reform) and the entrepreneurial identity with the new self-financing scheme (the 2013 reform). In this respect, the interviewees argue that "the policies and guidelines implemented by the Ministry of Higher Education have allowed a certain kind of university autonomy in the development of their core activities and generation of income" (Interview UA7). In conjunction with university values, state commitments and social objectives, the Cuban university has introduced an innovation/entrepreneurial identity as a mechanism to maximize its social value. The second element was the integration and complete cycle of teaching, investigation, knowledge production, and technological commercialization. Based on the university's strategic vision and collaborative networks with productive sectors, both agents faced an adaptation process looking for sustainable outcomes with practical applications and social impacts. The third element was a hybrid infrastructure created to manage knowledge. It also allowed the inclusion of students in university-industry projects oriented towards knowledge generation and transfer processes. According to the productive sector, "the biggest novelty was the new university learning production model, which included the participation of undergraduate students in the development of technological projects. It has been an excellent certification of students' capabilities" (Interview I6). This role has been crucial in the training of technology assimilating workers. Therefore, ensuring the human capital required in the research, development, and innovation process as part of the professional development cycle.

4.3. The Challenges of a Social, Innovative, and Entrepreneurial Identity

Cuban universities have adopted the traditional business model focused on achieving the teaching activities (i.e., educational programs and vocational education programs). Therefore, by adopting the business model innovation literature, the transformation of the Cuban university model still faces three crucial challenges according to the interviews. The first challenge is the ability to explore and exploit opportunities to diversify income. It is aligned with findings of previous studies that explain that the diversification of income implies the understanding of potential value for the stakeholders, as well as their potential involvement in the co-creation and definition of this value [21]. Moreover, the entrepreneurial and innovative role of the university also demands legitimization within a society characterized by a national culture oriented toward a social perspective. Therefore, it also requires the support of the State via regulations, as well as social norms [11]. The second challenge is the balance between an entrepreneurial and social identity. According to the university actors, "the idea is to approach a complementary self-financing system where every participant obtains benefits from their contributions based on the social essence of the Cuban university" (Interview UA1). The entrepreneurial identity implies new capabilities in the university community [31]. In this line, the challenge has been recognizing as an agent of change that reorganizes organizational structures by aligning the social mission (training qualified professionals), the innovative mission (making contributions in science, technology, and innovation for the development of the country), and the entrepreneurial mission (diversify income streams and technological commercialization). As a result, the university will serve society by improving the quality of life through technological innovations and human capital [19]. The third challenge is the exploitation of competitive advantages by creating a network and alliances with crucial partners or agents [42,43]. It implies the engagement of capabilities for stimulating informal and formal relationships with networks, alliances, or collaboration partners.

5. Conclusions

This paper proposed a conceptual model to analyze the transition process of the university located in socialist economies into a social, innovative, and entrepreneurial organization. By adopting the prospective case study approach, we analyzed the identity transition of Cuban universities by exploring the business model. As the business model innovation is a tool that allows identifying the strategic university actions for generating and capturing value, this analysis also allowed identifying how Cuban universities aligned the social, innovative, and entrepreneurial identities.

Our findings showed insights about the determinants in the transition into a social, entrepreneurial and innovative identity (state regulation; the integration and complete cycle of teaching, investigation, knowledge production and technological commercialization; and hybrid infrastructures created to manage knowledge), as well as the challenges faced by Cuban universities (the ability to explore and exploit opportunities to diversify income; the balance between an entrepreneurial and social identity; the exploitation of competitive advantages by creating networks and alliances with crucial partners or agents). Our study contributes to the entrepreneurship literature by proposing a conceptual framework to understand the transition of universities located in socialist economies into social, entrepreneurial, and innovative organizations [8,10,31], as well as to the innovation literature by using business model innovation for operationalizing the aligning of universities' identities [21,45,47–49].

This research has several limitations. The first limitation has been the lack of evidence about the impacts of each identity of Cuban universities in terms of wellbeing, technological transformation, and economic development. Future research should explore the impacts generated by each university identity: social, innovative, and entrepreneurial. It demands longitudinal and in-depth studies [35]. The second limitation is the lack of evidence about the link with stakeholders. Our interviews provide insights about the contribution of Cuban universities to the productive sector. However, the stakeholder's perspective should be included in the future research agenda [10,34]. The third limitation is the lack of evidence about the effectiveness of the Cuban State policies. Although the strategy was designed to improve the country's competitiveness, there is no evidence about the achievement of the expected outcomes [18,47,48]. The fourth limitation is associated with the metrics used in our semi-structured interviews. Future research should consider the implementation of quantitative metrics that allow understanding of interviewees' perceptions as well as explore causal relationships.

Several implications emerge from this study. An important implication is that Cuban universities must adopt an entrepreneurial and social perspective. From this point of view, the implementation of a social entrepreneurial business model may be an alternative to ensure the immersion of the university community into the transformation process. The entrepreneurial and social identity may ensure the sustainability of the university as well as its contribution to society. The new university's identity demands an entrepreneurial mindset and culture within the university community (students, academics, university managers) and among its stakeholders. At the country level, it implies the participation of multiple actors (government, university, productive sector, and society) in the sensibilization process for a better understanding of the entrepreneurship phenomenon in the university context. At the university level, it also implies the evolution of the university's routines towards capabilities for sensing opportunities to generate added value to the society (productive sectors' needs and demands), seizing the resources to address the opportunities (channels and collaborations), and transforming the resources into innovative outputs (research agendas, technology transfer, and socio-economic development) [49].

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Appendix A

Table A1. Data analysis.

Traditional Model

ID	Associations				Core Activities			Resources and Capabilities			Added Value			Clients			Income		
	A1	A2	A3	A4	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3	E4	F1	F2
ua1	x	x		x	x	x	x	x	x	x	x		x	x	x		x	x	
ua2	x				x	x	x	x	x	x		x		x	x	x	x	x	
ua3	x	x	x		x	x	x	x	x	x	x	x		x			x	x	x
ua4	x	x			x	x	x	x	x	x		x	x	x		x			x
ua5	x				x	x	x	x	x	x		x		x			x	x	x
ua6	x	x			x	x	x	x	x	x	x	x		x	x	x		x	x
ua7	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
ua8	x	x			x	x	x	x	x	x		x		x	x		x		x
ua9	x		x	x	x	x	x	x	x	x	x	x		x		x	x		x
ua10	x		x	x	x	x	x	x	x	x			x	x	x	x		x	
ua11	x				x	x	x	x	x	x	x		x		x	x		x	x
i1	x	x			x	x	x	x	x	x	x		x	x	x	x	x		
i2	x				x	x	x	x	x	x	x		x	x	x	x	x		x
i3	x	x			x	x	x	x	x	x	x			x	x				x
i4	x	x	x		x	x	x	x	x	x	x	x	x	x		x			x
i5	x				x	x	x	x	x	x	x	x	x	x		x	x	x	
i6	x	x			x	x	x	x	x	x	x		x	x	x	x	x	x	x
p1	x	x	x		x	x	x	x	x	x	x		x	x		x		x	
p2	x	x			x	x	x	x	x			x	x	x		x	x		x
p3	x	xx			x	x	x	x		x		x		x		x	x	x	x

Business Model Innovation

ID	Associations			Core Activities			Resources and Capabilities			Added Value			Clients			Income				Associations			
	F3	F4	A5	A6	A7	A8	B4	B5	B6	C1	C4	C5	D4	D5	D6	E1	E2	E3	E4	F5	F6	F7	F8
ua1	x	x		x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x		
ua2	x		x	x	x			x	x	x		x	x			x		x	x	x	x	x	x
ua3	x	x	x		x	x	x	x	x	x	x		x	x		x		x	x	x	x	x	x
ua4	x	x	x		x	x	x	x	x	x	x		x	x		x	x	x	x	x	x	x	x
ua5	x	x	x	x			x	x	x	x	x		x	x	x	x	x	x		x	x	x	x
ua6	x	x	x	x	x		x	x	x	x	x		x	x	x	x		x	x	x	x	x	x
ua7	x		x		x	x	x	x	x	x	x		x		x	x		x	x	x	x		
ua8	x		x	x	x	x			x	x	x		x	x	x			x		x	x		x
ua9	x	x	x	x	x	x			x	x	x	x	x		x	x		x		x	x	x	
ua10	x		x	x	x	x	x		x	x			x				x			x	x		x
ua11	x		x			x	x	x	x	x			x				x			x	x		x
i1	x	x	x		x	x	x	x	x	x	x		x	x			x	x	x	x	x	x	x
i2	x				x			x	x	x			x	x			x		x	x	x	x	x
i3	x	x		x	x	x		x	x	x			x		x		x		x	x	x	x	x
i4	x	x	x	x		x	x	x	x	x	x		x		x		x		x	x	x	x	x
i5	x	x	x	x	x			x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
i6	x	x		x	x		x	x	x	x	x		x		x		x			x	x	x	x
p1	x	x	x	x	x		x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
p2	x	x	x	x	x	x	x	x	x	x		x	x	x	x		x	x	x		x	x	x
p3	x		x		x	x	x	x	x	x	x	x	x	x	x		x		x	x	x	x	

Associations: A1: State; A2: Ministries; A3: Embassies; A4: Universities; A5: Productive sector; A6: Research institutions and centers; A7: Foreign Universities; A8: Associations. **Core activities**: B1: Teaching; B2: Research; B3: Extension; B4: Product development; B5: Technology Transfer; B6: Post-graduate programs. **Resources and Capabilities**: C1: university community (students, professors, researchers); C2: infrastructures and external agents; C3: budget; C4: R&D specialists; C5: Entrepreneurial leadership. **Value-added**: D1: Qualified students; D2: Teaching oriented to the labor market; D3: Cutting edge knowledge; D4: Post-graduate programs; D5: Technological/innovations; D6: Specialized services. **Clients**: E1: State; E2: Employers, enterprises; E3: Universities, research community and research centers; E4: students and society. **Income**: F1: University recognition; F2: Scientific production; F3: Government budget; F4: Scholarship funds and enrolment; F5: Tuition from international students; F6: Fees of scientific events; F7: Specialized services; F8: R&D collaboration.

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Article

Building University-Industry Co-Innovation Networks in Transnational Innovation Ecosystems: Towards a Transdisciplinary Approach of Integrating Social Sciences and Artificial Intelligence

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Abstract: This paper presents a potential solution to fill a gap in both research and practice that there are few interactions between transnational industry cooperation (TIC) and transnational university cooperation (TUC) in transnational innovation ecosystems. To strengthen the synergies between TIC and TUC for innovation, the first step is to match suitable industrial firms from two countries for collaboration through their common connections to transnational university/academic partnerships. Our proposed matching solution is based on the integration of social science theories and specific artificial intelligence (AI) techniques. While the insights of social sciences, e.g., innovation studies and social network theory, have potential to answer the question of why TIC and TUC should be looked at as synergetic entities with elaborated conceptualization, the method of machine learning, as one specific technic off AI, can help answer the question of how to realize that synergy. On the way towards a transdisciplinary approach to TIC and TUC synergy building, or creating transnational university-industry co-innovation networks, the paper takes an initial step by examining what the supports and gaps of existing studies on the topic are, and using the context of EU–China science, technology and innovation cooperation as a testbed. This is followed by the introduction of our proposed approach and our suggestions for future research.

Keywords: transnational industry cooperation; transnational university cooperation; transnational innovation ecosystem; EU–China; science, technology and innovation cooperation; transdisciplinary approach; artificial intelligence; machine learning

1. Introduction

While there is growing awareness of the role of digital technologies in transforming organizations and social relationships [1], the new economy (called platform economy or digital platform economy) based on digital technologies is changing the nature of globalization [2], in which the focus has been shifted from countries (globalization 1.0) and companies (globalization 2.0) to individuals and groups (globalization 3.0) [3]. The involvement of individuals or citizens in multi-faced social life is crucial in sustainable development [4–6] in ecological, social, and economic dimensions [7]. In this paper, we try to bring interactions of key actors in transnational innovation processes, previously mainly explored through social science approaches, into the digital domain, applying some specific artificial intelligence (AI) technologies, i.e., machine learning and knowledge representation and reasoning. Our focus is on the relations between transnational industry cooperation (TIC) and transnational university cooperation (TUC) in transnational innovation ecosystems (see more descriptions about the concept of transnational innovation ecosystem in the following section), which share basic assumptions of sustainability and globalization 3.0. TIC is concentrated on joint research and development (R&D) and co-production; TUC is mainly concerned with academic research collaboration. The research problem of TIC and TUC synergy building, as described below, has emerged in the context of innovation studies and their adjacent fields. We try to resolve the problem by integrating relevant studies in social sciences (in the fields of innovation studies, higher education research and international relations with respect to EU and China) and AI technologies (i.e., machine learning and knowledge representation and reasoning).

The literature of innovation studies, which conceptualizes reciprocal relations and proactive interactions between universities, industry, government and citizens for promoting innovation [8,9], stresses the importance of synergy building between cross-sector organizations. Particularly, university and industry (U–I) interactions constitute a core area in innovation studies [10]. While the innovation processes are becoming globally interconnected [11–14], there is also an urgent demand to extend cross-sectoral organizational synergy building to the transnational context. For instance, it has been evidenced, though mainly in the industrial context, that technological capabilities for innovation are dispersed in international innovation networks [15] and the degree of R&D internationalization is increasing [16,17]. Thus, actors from both university and industry sectors, as key contributors to technological capabilities and R&D, are likely to become international [13].

However, academic research is far behind the needs for further integration between TIC and TUC arising from the practices of transnational STI cooperation. Although one widely shared view in innovation studies is that universities have a prominent role in the national or regional innovation system, e.g., through co-creation partnerships with industry [8,18,19], the research of U–I cooperation in transnational contexts is rare in the literature. For instance, in their literature review of U–I international knowledge transfer, Govind and Küttim [20] only found 26 articles (mainly in the fields of innovation studies and higher education research) meeting their search criteria in the Scopus and Web of Science databases. Amongst the 26 articles, U–I interactions in the transnational context are mainly seen in the form of universities from one country interacting with enterprises from another country, which is echoed in other literature e.g., [21–23]. Other studies deal with joint R&D between universities and branches of international companies e.g., [24]. The patterns of transnational U–I interactions examined in the existing literature can be illustrated in Figure 1.

When innovation systems become global [25] or internationalized [26], international university cooperation could added value to the process [27]. Some rare studies e.g., [23,28–30] do touch upon the issues of how TUC could be aligned with and supportive of broader societal priorities and development goals in transnational contexts. However, there is a lack of profound exploration in this area, particularly from theoretical and methodological perspectives.

In the context of transnational innovation networks, the interactions between TIC and TUC can be understood as synergetic entities or transnational U–I co-innovation networks (Figure 2). In such networks, new ideas and approaches from various internal and external sources are integrated in a platform to generate shared values [31]. The core elements of co-innovation include "collaboration, coordination, co-creation, convergence, and complementary" [32] (p. 361).

Figure 2 demonstrates that two industrial firms that are unfamiliar with each other, respectively from Country A and Country B, could be connected for potential collaboration by utilizing their common connections to existing university collaborations (especially individual collaborators) between the two countries. Although our focus is on how TUC can support TIC, once TIC and TUC synergetic entities are formed, the TIC would enhance the quality and value of TUC.

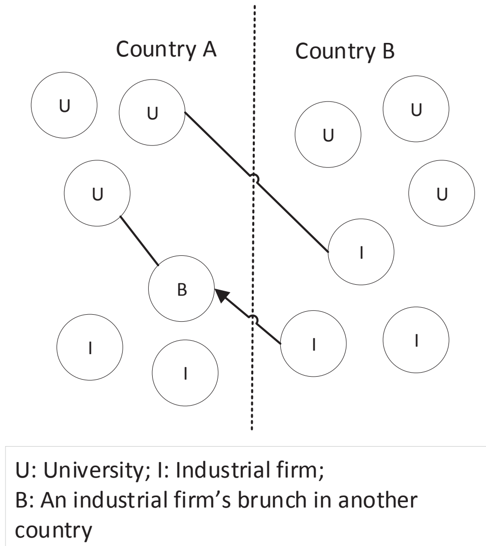

Figure 1. Examples of transnational university and industry (U–I) interactions examined in the existing literature.

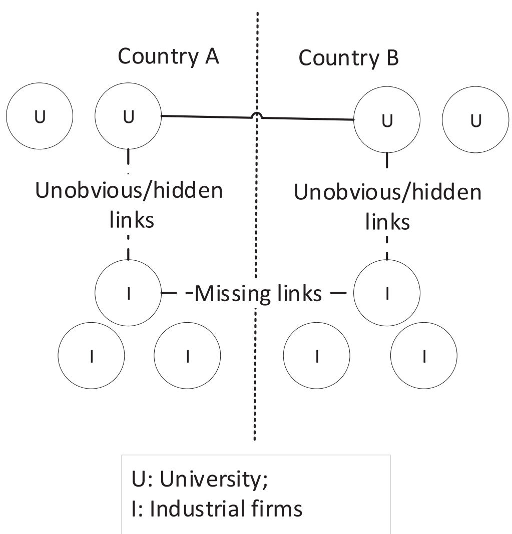

Figure 2. The transnational industry cooperation (TIC) and transnational university cooperation (TUC) synergetic entities (or transnational U–I co-innovation networks) to be tackled in our research.

Compared to existing studies on U–I interactions in transnational context (Figure 1), our investigation of U–I co-innovation networks (Figure 2) is novel in two aspects. First, although the subject of university and industry interactions in transnational context is not new in research, our study is different to existing approaches by discovering unobvious/hidden links between TUC and TIC. When links are hidden, it means that the links are unobvious or the data revealing the links are scarce or not apparent. Second, when it comes TIC, we not only look at existing collaboration of industrial firms across countries as examined by current studies, but specifically explore how missing links between potential transnational industrial partners could be bridged through utilizing the hidden links. The dash lines in Figure 2 represent either hidden or missing links that are rarely examined in the existing studies but will be the focus of our proposed approach. Missing links demonstrate that the actors with potential for reciprocal collaboration are not connected. However, the actors can be connected by leveraging the hidden links. Third, while current research related to the topic are mainly in the field social science studies, we seek an approach integrating insights of both social sciences and AI technology.

The lack of interaction between TIC and TUC is also seen in the practices of transnational science, technology and innovation (STI) cooperation. For instance, as indicated by the first author's recent interviews of actors involved in EU–China STI cooperation, in the EU–China context, when European high-tech firms, especially small- and medium-sized enterprises (SMEs), seek Chinese counterparts for cooperation, they normally go directly to the industry sector, sometimes through business brokers. As a result, the Chinese partners that first appear to them are not necessarily the most suitable ones. This could be explained by three causes. First, the business brokers, e.g., consulting companies or governmental business promotion agencies, have a limited pool of Chinese companies as candidates to be matched with European SMEs. Second, when matching collaborators, human decisions are often subject to the "homophily principle"—a tendency in which people form ties with similar others [33]. Selecting a "friend of a friend" helps strengthen existing social clusters [33], but does not help to reach those unknown communities and individuals [34], who could potentially contribute to innovation [35]. Third, although one may notice the limitation of professional social matching based on human decisions, it is difficult to find suitable tools and data to resolve the problem [34].

Our proposition is that European and Chinese industrial firms can be best matched through their connections to existing university cooperation between both sides. In so doing, transnational U–I co-innovation networks are formed, which are crucial for enhancing the performance of EU–China STI cooperation. This has also been implied by the interviews mentioned above.

Now there is a great opportunity to exploit EU–China university cooperation to support EU–China industry cooperation, because EU–China higher education cooperation has reached an unprecedented level, demonstrated by not only a large scale of student/staff exchange but also increasingly deeper research collaboration and joint education programs [30]. For instance, there were 383 participating institutions from China in 274 projects in the EU's Seventh Framework Program (2007–2013). Although China is no longer considered to be a beneficiary country in the Horizon 2020, the Chinese Ministry of Science and Technology provides co-funding to support Chinese research organizations involved in the EU's Horizon 2020 projects. In the Web of Science database, the number of co-authored publications between Chinese and European authors has increased from 12,669 in 2011 to 35,218 in 2018.

The EU–China context is used as a testbed for three reasons. First, there is huge potential for STI cooperation between the EU and China. Second, the scales of both higher education and industry in the EU and China are tremendous, which provide abundant data for testing and application. Third, since the EU and China have different, sometimes contrasting, social structures and value systems, if we can find effective solutions to build TIC and TUC synergies in EU–China STI cooperation, the approach is likely to be applied (with possible adjustment) in other transnational contexts.

While using a specific EU–China context helps illustrate our research problem, the underlying research gaps concerning TIC and TUC synergy building are general. To narrow the gaps, we must first clearly see what the gaps are. Thus, this paper will analyze how the state-of-the-art studies have shed light on the following questions as well as limitations in answering these questions:

- Why should TIC and TUC be looked at as synergetic entities?
- How can the synergy building be theoretically elucidated?
- How can the synergy building be methodologically realized?

After that, we will present our proposed approach in brief, and discuss how it could help advance the frontier of research on the topic. It should be mentioned that the paper is primarily on the conceptual level. When it comes to our proposed AI-based approach we focus on developing operating principles rather than final technological solutions. The method in this paper is primarily based on reviewing, analyzing and synthesizing relevant literature.

2. Why Should TIC and TUC Be Looked at as Synergetic Entities?

The synergy building between TIC and TUC in the context of EU–China STI cooperation, which takes place when innovation ecosystems of both the EU and China come across (as illustrated in Figure 3). Despite our focus on the sectors of university and industry, it should be noted that the EU–China transnational innovation ecosystem consists not only of enterprises and universities but also governmental agencies and various intermediary organizations. When building the TIC and TUC co-innovation networks in the EU–China context, it is essential to discover the hidden links and bridge the missing links as show in Figure 3.

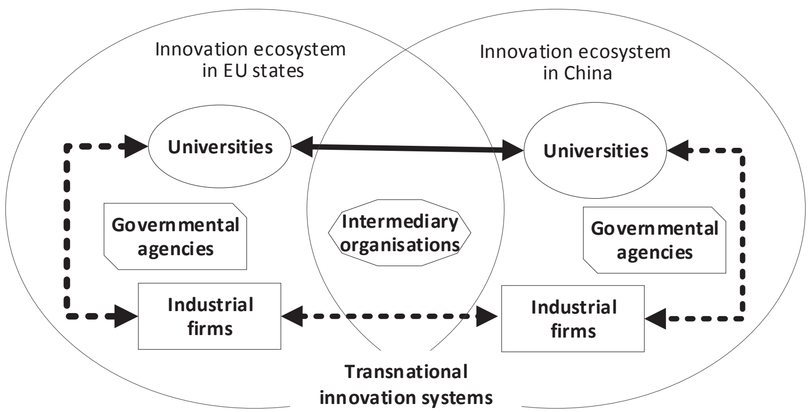

Figure 3. EU–China university cooperation and EU–China industry cooperation in the context of the EU–China transnational innovation ecosystem.

The insights of the following three research areas may provide hints on why TIC and TUC synergy building (in the EU–China context) is necessary, namely (1) the conceptualization of transnational innovation ecosystems, (2) research on universities' third mission and (3) studies on EU–China STI cooperation.

2.1. Transnational Innovation Ecosystems

Due to the increasing importance of international linkages in the knowledge-based society and a growing public awareness of the need for environmentally sustainable economic development, the term "transnational or global innovation ecosystem" has gradually become popular in both scholarly literature and policy rhetoric. While the concept of the transnational ecosystem has been applied on both the system level [36] and the sector and company levels [25], what is most relevant to the present research is the system-level literature. A transnational innovation ecosystem generally refers to the integration process between two or more innovation ecosystems across national borders with different levels of transnational integration [37,38].

To further understand the transnational innovation ecosystem, one must understand what an innovation ecosystem is. In a commonly cited definition, innovation ecosystems are regarded as "complex relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation" [39] (p. 2). The innovation ecosystem shares most of its features with the innovation system, which consists of complex functions and interactions amongst various organizations and institutions [40,41]. What is new in the innovation ecosystem is its ecological aspect, characterized by the interdependency among different collaborative actors and the co-evolution/co-creation that binds them together over time, along with the sustainable development dimension [42–44].

The literature on transnational innovation ecosystem has indicated, though implicitly, that TIC and TUC could be looked at as synergetic entities. Based on analyzing several definitions of "ecosystem", Sotarauta, Heinonen, Sorvisto, and Kolehmainen [38] suggested several key features of the innovation ecosystem, including "interconnectedness" (everything is connected to everything), "organic nature" (the system evolves through its components' continuous adaptation to changing situations) and being "multi-locational" (knowledge flows and innovation processes take place in multiple geographical locations) (pp. 31–32). All these infer that complex interactions amongst a variety of (transnational and cross-sectoral) actors shape adaptation processes in an innovation ecosystem. Such generic inferences may imply that TIC and TUC could form symbiotic relations to better adapt to increasingly complex and fast-changing environments.

Some other studies draw specific attention to the role of universities in the transnational innovation ecosystem. In a report on case studies of transnational innovation systems, Chaminade and Nielsen [36] addressed the importance of identifying already existing transnational initiatives (i.e., university and industry sectors) in forming transnational innovation systems. They suggested that available resources should support existing bottom-up transnational initiatives rather than start new ones from scratch in a top-down matter. Raunio, et al. [45] noted that "the transnational innovation infrastructures could be based more on the activities of universities or regional actors" (p. 2). They further suggested that the global university campuses could potentially help bridge the gap between the national innovation system and relevant innovation systems abroad.

2.2. Universities' Third Mission

One may intuitively assume that transnational university cooperation in the transnational innovation ecosystem is a well-studied topic. This is because of a widely shared understanding regarding the prominent role of universities in national or regional innovation systems, reflected in studies dealing with the third mission of universities [46], both in higher education research (inside-out view) e.g., [18,47–49] and innovation system studies literature (outside-in view) e.g., [8,40,41,50]. As recently stated by UNESCO's Chief of Higher Education, Peter J. Wells, "Perhaps never before in recent history has the role of higher education been so intricately tied to the economic, social, and environmental fabric of the modern world" [51] (p. 31). Since the knowledge-based society is becoming more globally interconnected, universities' societal engagement should also be conducted on a global scale.

However, most studies on transnational university cooperation are in the field of internationalization of higher education, which is primarily concerned with the teaching and research missions of universities [52,53] or with the mobility of knowledge from the perspective of human geography [54]. The studies on international graduate employability e.g., [55,56] are closest to addressing the relevance of international higher education to industry in a global context.

Nevertheless, some rare studies e.g., [23,28,29] do shed light on how transnational university cooperation could be aligned with and supportive of broader societal priorities and development goals in transnational contexts. Heide, Sijde, and Terlouw [28] explicitly explored transnational university cooperation in knowledge transfer. However, the authors solely focused on transnational research cooperation in the EU context mainly concerning types of cooperation and universities' motivations for the cooperation, and did not extend their discussion to the links of transnational university cooperation to industry sectors. Cai [30] clearly stated that China-EU higher education cooperation should be planned and developed in the broader context of Sino-EU strategic partnership building, as a call for further research.

2.3. EU–China Transnational STI Cooperation

The booming practices of EU–China STI cooperation have rarely been explored scientifically, remaining marginal in EU–China studies. The existing literature on the EU–China relationship e.g., [57–59] deals with three main pillars of cooperation between the EU and China, namely the strategic dialogue initiated in 2005, the economic and trade dialogue commenced in 2008 and the "People-to-People Dialogue" launched in 2012 to improve cooperation in education, culture, youth and research.

However, the necessity of TIC and TUC synergy building can be foreseen in the burgeoning interests of the EU and China in STI cooperation, which has been expedited by the signing of the "EU–China Innovation Cooperation Dialogue" in 2012. The Dialogue complements and ensures synergy with the "Agreement on Science and Technology Cooperation between the EU and China" in 1998. The innovation cooperation involves both industrial organizations and universities (as well as research institutes) [60]. The progress of EU–China STI cooperation in both higher education and industry is not merely a matter of quantity; its very nature is undergoing a transformation.

The nature of the EU industry's cooperation with China is changing from a conception of China as an important market and trade partner to that of an innovation partner [61,62], because China is not only the second largest economy in the world but also a powerful STI player [63]. China has overtaken the United States in terms of total number of science publications [64] and dominates a global ranking of the most-cited research papers published in the 30 most popular technology fields [65]. In such a context, EU–China industry cooperation is not confined to the business domain but expanded to the sector of knowledge generation.

In the field of higher education, EU–China university cooperation is facing increasing demands from society and stakeholders calling for universities to adapt their internationalization strategy from an emphasis on international scholarship exchange to being more responsible regarding the broader needs to develop the EU–China partnership [30]. This echoes the general trend in the internationalization of higher education in the EU, which has been increasingly influenced by the globalization of economics and societies, as well as the importance of knowledge in economic development and competition [66].

2.4. Limitations of Existing Literature

The literature on both transnational innovation ecosystems and universities' third mission has implied why synergy building between TIC and TUC is important in transnational innovation ecosystems, but the inferences are implicit and hypothetical. Both theoretical and empirical efforts on the topic are lacking. Recent studies and reports on EU–China relations indicate that the changing nature of EU–China cooperation requires synergy building between cooperation in both the university and industry sectors. However, it is surprising how little interaction exists between the two areas of cooperation on both the levels of policy-making and organizational practice. Neither has synergy been addressed in research on EU–China STI cooperation, which tends to report on cooperation separately in the university sector e.g., [67] and the industry sector e.g., [68].

3. How Can the TIC and TUC Synergy Building Be Theoretically Elucidated?

Although state-of-the-art research reflects fast-growing attention to TIC and TUC synergy building, there are no theoretical frameworks that elucidate relations amongst diverse actors in transnational innovation ecosystems. Even the concept of the innovation ecosystem exists on a high level of abstraction and is used loosely. It is often understood as a metaphor rather than as a theory or framework [42]. Oh, Phillips, Park, and Lee [42] noted that the mimetic quality of the term "innovation ecosystem" mainly appeals to the news media, demonstrating the public relations value of the term, but not its value in research. They found "few academic articles using 'innovation ecosystem' in a manner that would distinguish an innovation ecosystem from an innovation system" [42]. Along the same lines, Ritala and Almpanopoulou [69] called for future research to improve the conceptual, theoretical and empirical rigor regarding the notion of the innovation ecosystem. Nevertheless, some other social science theories may provide useful, theoretical accounts of the mechanisms underlying the interactions between TIC and TUC, though in a direct manner, such as the Helix models of innovation, institutional theory and social network theory.

3.1. Helix Models of Innovation

Helix models of innovation, discussed here, include three concepts, namely Triple Helix Model [8], Quadruple Helix Model [9], and Triple Helix of sustainability [70]. The three concepts with different emphasis on the key dimensions innovation and societal development can supplement one another for a comprehensive understanding of the nature of contemporary society with respect to innovation.

Although the thesis of the Triple Helix Model [71] was originally developed based on empirical observations of successful regional innovation systems, its core theoretical assumptions can be applied to transnational or global contexts. Following this perspective, a transnational innovation ecosystem consists of the triple helix interactions of three functional spaces, namely transnational knowledge space, transnational innovation space and transnational consensus space [8,72]. The three spaces are respectively related to three functions, namely novelty production, normative control and wealth generation [73]. In each space, there are three overlapping spheres of transnational cooperation evolving in the respective sectors of university, industry and government, but one kind of sphere may outweigh the others. Such a Triple Helix Model of transnational innovation ecosystem is illustrated in Figure 4.

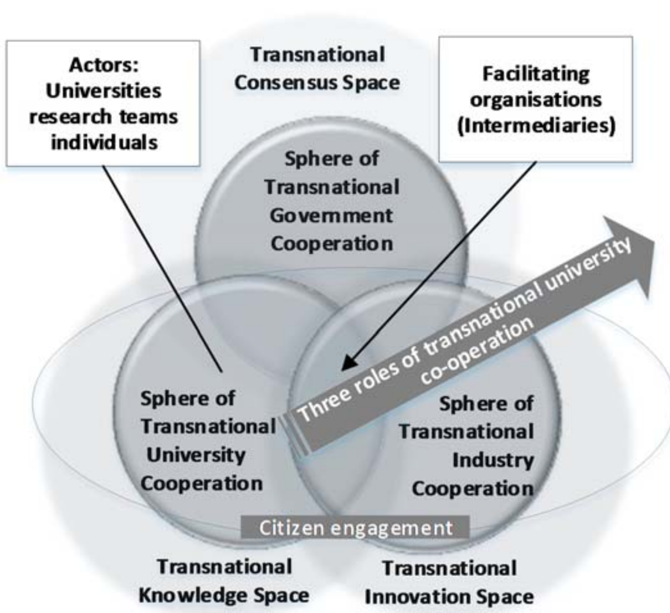

Figure 4. Triple Helix Model of the transnational innovation ecosystem.

Carayannis and Campbell [9] developed the Quadruple Helix model from the basis of the Triple Helix in order to address the “media-based and “culture-based public”, “arts, artistic research and arts-based innovation” (p. 218), by adding the ‘fourth helix’ also called as the “civil society” [74] (p. 5). The core rationale of Quadruple Helix centers on Mode 3 knowledge production, which is developed on the basis of Mode I and Mode 2 types of knowledge production by Gibbons et al. [75], who predicted a shift in knowledge production from Mode 1 to Mode 2. Mode 1 refers to basic university research on disciplinary basis. The Mode 2 in turn, emphasizes knowledge application, interdisciplinary research and problem solving. Mode 3 type of knowledge production is an extension for Mode 1 and 2 type of knowledge production [75]. It "allows and emphasizes the co-existence and co-evolution of different knowledge and innovation paradigms" [9] (p. 201). Mode 3 is the nexus of the emerging 21st century innovation ecosystem, where people, culture and technology meet and interact to catalyze creativity, trigger invention, and accelerate innovation across scientific and technological disciplines, public and private sectors, in a top-down, policy-driven as well as bottom-up, entrepreneurship-empowered fashion [9,76].There is a seemingly shared view about the possible extension from Triple Helix to Quadruple Helix (adding civil society as the fourth helix) [76,77]. However, we take the position that civil society is considered too important to be merely treated as an additional helix in the Quadruple Helix. Rather, it is an institutional foundation [78,79] or "a launch pad for the take-off of triple helix interactions" [72] (p. 20). Thus, citizens' engagement is positioned in Figure 4 as the foundation of transnational Triple Helix interactions. Nevertheless, we admit that the Triple Helix Model has not explicitly addressed the emerging phenomena or new characteristics in innovation ecosystems. Meanwhile, we consider that the relatively more elaborated theoretical foundations of Triple Helix Model may help enhance the explanation power of Quadruple Helix [80], which was conceptualized to cope with the innovation ecosystem of the 21st Century [6].

Moreover, Triple Helix model is needed to be further improved with the dimension of sustainable development. In this regards, Scalia, Barile, Saviano and Farioli [70] suggested the model of Triple Helix of sustainability based on both the concept of Triple Bottom Lines of Elkington [7] and the Triple Helix Model of innovation Leydesdorff and Etzkowitz [81]. It implies that interactions between society, economy and environment must be considered when studying innovation, either approached by the Triple Helix Model or Quadruple Helix Model.

The foundational statement of the Triple Helix Model is that the interactions between university, industry, and government sectors provide optimal conditions for innovation [8]. The core mechanism underlying these interactions is "taking the role of the other" [8]. Organizations taking on non-traditional roles are viewed as a major potential source of innovation. In the meantime, they still retain their traditional functions. To add the sustainability or ecosystem dimension in the Triple Helix model, the role of university must go beyond production and capitalization of knowledge [82], as main function of the third mission of universities.

In transnational contexts, the roles of transnational university cooperation are more than producing and transferring knowledge across national borders. There are two additional roles, namely fostering institutional change (concerning norms and values) in transnational innovation ecosystems and building trust between various actors in the systems [83]. The development of innovation systems is largely concerned with institutional change [40,41] and successful cooperation in research, development, and innovation relies on trust between the collaborators [84]. Both institutional change and trust building are even more salient in transnational innovation ecosystems because of the more complicated institutional configurations and distance between the collaborators in a transnational context [36]. The role of university as institutional entrepreneur [85] or social trust builder [86] is relevant to sustainable development because the it brings in social capital into the analytical foci of innovation ecosystem [6], in addition to human and financial capital as emphasizes of the concept of university's "third mission". The two roles concerning institutional change and trust building can be respectively explained by institutional logics theory and social network theory.

3.2. Institutional Theory

From the perspective of institutional theory, there are two essential issues in forming an innovation (eco)system, namely institutional conditions enabling innovation [78] and the agency of actors to change the institutional context [87,88]. These two factors can be respectively explained by the institutional logics approach and the notion of institutional entrepreneurship.

Institutional logic is defined as "a set of material practices and symbolic constructions" that constitute an institutional order's "organizing principle" and are "available to organizations and individuals to elaborate" [89] (p. 248). The institutional logics approach helps better explain how institutions both enable and constrain action by incorporating macro structure, local culture and human agency [90]. One central pervasive argument of the institutional logics perspective is that multiple and contending logics provide the dynamic for potential change in both organizations and societies [90].

The notion of institutional entrepreneurship, which was originally introduced by DiMaggio [91] as a way to reintroduce actors' agency into institutional analysis, refers to the activities of institutional entrepreneurs, who not only initiate diverse changes in the institutional environment but also actively participate in the implementation of such changes [92]. Institutional entrepreneurs may initiate institutional change intentionally or unintentionally. They may have a high or low social status and "can be organizations or groups of organizations, or individuals or groups of individuals" [92] (p. 68). Leca, et al. [93] reported that institutional entrepreneurship is likely to take place in contexts with conflicting institutional arrangements. Battilana, Leca and Boxenbaum [94] stated that "joint actions and interactions between institutional entrepreneurs" (p. 77) provide conditions conducive to institutional entrepreneurship.

In the Triple Helix Model, for instance, there is mingling of the logics of state, market/corporate and profession, which respectively dominate in the spheres of government, industry, and academia [94]. In transnational contexts, the institutional configurations would be more complex. According to the institutional logics perspective, crossing organizational field operations, e.g., between the fields of university and industry, is likely to generate novelty [95]. The multiple and sometimes hybrid institutional environments, created by triple helix interactions, also forester institutional entrepreneurs.

3.3. Social Network Theory

The social network theory could provide useful hints regarding where and how actors crossing sectors and national borders can be connected or can collaborate for synergy building. For instance, in his seminal work titled *Strength of Weak Ties*, Granovetter [96] contends that in the case of job hunting, what is most helpful for the job seekers is not strong ties within their dense networks of relatives and friends for social support. Rather, it is the connections derived from weak ties, composed of distant acquaintances, which give access to new (not redundant) information and job offers. In other words, the strength of weak ties lies in its nature of being a source of novel information. Burt [97] put forward that social networks, especially in their function of facilitating weak ties that bridge dense networks, reflect the effect of "social capital" [98]. Instead of using the concept of "weak tie", Burt [99] coined the concept of the "structural hole". A structural hole refers to a lack of connection between two nodes (e.g., two individuals who have complementary sources of information), and social capital can be best realized through the brokerage of that structural hole. The underlying assumption is:

> Opinion and behavior are more homogeneous within than between groups, so people connected across groups are more familiar with alternative ways of thinking and behaving. Brokerage across the structural holes between groups provides a vision of options otherwise unseen, which is the mechanism by which brokerage becomes social capital. [100] (p. 349)

When applying social network theory in the context of innovation, it has been suggested that stimulating innovation within networks requires a combination of both strong and weak ties [101–103]. "Weak ties aid exploration (the generation of new ideas), whereas strong ties aid exploitation (the implementation of new ideas)" [35] (p. 212). The creation and diffusion of innovation are mostly attributed to weak ties [104]. For instance, one reason why the Triple Helix Model [8,71] provides optimal conditions for innovation is because through the interactions of university, industry and government—three traditionally not overly connected sectors or networks—a large variety of new ideas and technologies are likely to be created.

Trustworthy social relationships and common institutional frameworks are also beneficial for interactive learning and innovation [105]. While the most useful knowledge/ideas would come from weak ties, one challenge is that the trust between actors connected by weak ties might be low. The trust issue is even more important when the knowledge is tacit. Increasing the level of trust is crucial to enhancing the performance of weak ties in knowledge transfer [106].

3.4. Limitations of Existing Literature

The literature on the Helix models of innovation [8,9,70,71], institutional logics [90] and social network theory [96,97] may somewhat explain the mechanisms underlying the interactions between TIC and TUC from the perspectives of overlapping roles, institutional change and trustworthy relationship building. However, there is still a big gap regarding comprehensively theorizing the synergy building between TIC and TUC. Specific limitations of these theories are outlined below.

First, the theories focus on relations between obvious actors, and are not designed to identify and analyze unobvious or hidden relations. For instance, while the role of brokers in the innovation process has been strongly indicated by the social network theory and evidenced in empirical studies, the challenge in practice is how to proactively identify them. Sometimes, even potential brokers might not be aware of their position and potential for network building.

Second, social network theory tends to consider single nodes (either individuals or organizations) as brokers and there is no attempt to think of brokers in other formats. It excludes the assumption that a pair of nodes, e.g., in the form of a transnational university research partnership, together could play the role of filling structural holes.

Third, the current theoretical accounts about university and industry relations address the domestic context and need to be adjusted for analyzing phenomena in transnational innovation ecosystems.

4. How Can the TIC and TUC Synergy Building Be Methodologically Realized?

Although TIC and TUC synergy building is a new topic in research, some popular approaches in social and computer sciences can provide methodological bases for empirical exploration on how to build synergies between TIC and TUC, including identifying potential collaborators and building relations. These approaches are social network analysis, professional social matching and AI.

4.1. Social Network Analysis

Social network analysis (SNA) are the methods and techniques (primarily relying on computer-based statistical measures and link analysis algorithms) used for discovering patterns of interaction between social actors in social networks. Tabassum, et al. [107] have identified different types of SNA.

Traditional SNA includes statistical measures of social networks. The fundamental units in this analysis are vertices and edges. Vertices (or nodes) can refer to a wide variety of individual entities, such as people and organizations or publications, and an edge connects a pair of vertices that represent numerous kinds of (direct or indirect) relationships (such as communication, cooperation, friendship, and trade) between individual entities.

More recent SNA focuses on node identification and link prediction. Node identification is used to identify the most valuable or influential nodes in certain network settings. To support this kind of analysis, several link analysis algorithms are devised, amongst which the most popular ones are the HITS29 and Brin and Page [108] algorithms. Parallel to node identification is the analysis of link prediction, which predicts which links are more likely to appear in the future. More specifically, such SNA is used for predicting re-occurring links instead of new links [107]. Both node identification and link prediction are important approaches in synergy building between TIC and TUC.

The other two emerging SNA approaches deal with, respectively, community detection and evolving networks, which are useful for TIC and TIC synergy building. The former is concerned with communities in networks and the latter emphasizes networks that are generated in real time, which are not static but evolving [107]. The core of TIC and TUC synergy building is concerned with relations between two communities in a transnational innovation network. The evolving aspect is especially relevant to analyzing networks in an innovation ecosystem.

4.2. Professional Social Matching

Related to SNA, a recent approach to support human collaboration is social matching, which identifies and facilitates new social connections between people using computational techniques [109]. Professional social matching (PSM) matches individuals or groups for professional collaboration and co-creation of value. It covers a range of "organizational activities, including recruitment, headhunting, community building, and team formation within or across organizations as well as individually driven activities like mentoring, seeking advisory relationships, and general networking" [34].

Olsson, Huhtamäki, and Kärkkäinen [34] compared conventional PSM based on human decisions and the computational approach of PSM. It has been suggested by knowledge management studies that the most fruitful collaboration and the capacity for high innovation may result from complementary viewpoints amongst a diverse groups of actors [110]. Thus, the traditional approach of PSM may constrain such co-creative potential, because people tend to choose collaborators with similar mind-sets and professional experiences, as well as from a limited pool of candidates. The computational approach of PSM, however, can help identify optimal collaborators with supplementary capacities and bring them together for co-creation networks. However, the existing approaches are often too simplistic [34].

Olsson, Huhtamäki, and Kärkkäinen [34] also proposed that a more advanced PSM system to be developed in the future should focus on the following dimensions when matching collaborators:

- Identifying optimal combinations of human characteristics and professional aims in certain professional activities (i.e., matching qualities and goals).
- Recommending partners for co-creative purposes, such as for business partnerships or mentoring relationships (i.e., matching individuals).
- Optimizing team formations for a project (i.e., matching multiple actors).
- Identifying suitably complementary actors for networked value creation (i.e., matching at ecosystem level).
- Balancing the supply and demand in the job market by suggesting dedicated trainings or new job openings (i.e., matching on societal level).

4.3. Artificial Intelligence: Machine Learning (ML) and Knowledge Representation and Reasoning (KR and R)

AI applications have been in use for at least 30 years in the medical and industrial contexts, but the use of AI in the social sciences is a current trend. In a social context, AI could provide useful tools for discovering new social phenomena and for testing existing theories. The basis for such AI systems can be found in the computational graph theory, which was proven to work well in computer networks [111].

Many AI-based methodologies have been put forward to construct models based on mobility patterns and predict the behavior of people individually or as a group [112,113]. These include stochastic models such as Markov Models MM) [114] and Bayesian Networks (BN), as well as non-stochastic models such as Artificial Neural Networks (ANN) and Decision Trees (DT) [115]. While researchers have used ML techniques such as ANN and DT [116], the stochastic models are preferred over these due to the uncertainty in or unpredictability of human behavior [116]. In several studies e.g., [115,116] researchers have also used Bayesian Networks.

ML and KR and R are two major techniques of AI that have the potential to provide solutions to matching transnational industrial partners through their connections to transnational academic partnerships. While humans learn things by using their brains, in ML algorithms are used by computers and robots to learn automatically (without explicit instructions) [117]. ML algorithms are based on training data, a kind of sample data. Data mining, as a field of study within ML learning, "is one of the most effective alternatives to extract knowledge from the great volume of data, discovering hidden relationships, patterns and generating rules to predict and correlate data" [118] (p. 687). Such a technique has often been applied in social network analysis [119,120].

KR and R [121] focuses on implementing knowledge repositories built by semantic descriptions that can be interpreted by both humans and machines. There are many KR and R formalisms used to implement semantic models, such as ontologies, databases and semantic rules. The former formalism is getting attraction in several fields, such as in the industrial automation field [122,123], needing to build semantic models including information from different and interrelated concepts. One of the major benefits of using such technic is the possibility of adding a layer of reasoning in order to discover implicit knowledge from the explicit data graphs that are fed to the model. Further, ML and KR and R can be integrated to work on different layers of implementation, i.e., using them for different processing data format, syntax and semantics.

4.4. Limitations of Existing Approaches

While the three approaches supported by cutting-edge computational and computer technologies are useful for social network analysis and matching optimal collaborators, none of them can be directly used to match TIC and TUC in transnational innovation ecosystems for three reasons. First, although the recent development of social network analysis has shifted attention to node identification and link prediction, which are essential in TIC and TUC synergy building, the related methods are still lacking efficiency especially in discovering hidden links and bridging missing links as well as processing unstructured data as the focus our research [107]. Second, while computational professional social matching has been more effectively used in practice [34], it is rarely used in cross-sectoral and transnational contexts. Third, while AI benefits business life, technology and industry [124], it is rare to see any efforts placed in using AI to facilitate understandings of the social system in which industrial businesses and technological innovations are embedded. A particular challenge in the case of TIC and TUC synergy building is finding both suitable algorithms and training data.

5. Our Proposed Future Solution

To further explore the three research questions, we aim to develop a transdisciplinary approach of integrating social sciences studies and AI technology. While achieving such an ambitious goal will be a long process, we will present our preliminary thoughts about the approach here.

5.1. A Transdisciplinary Approach

Our proposed transdisciplinary approach integrates the following disciplines and/or research fields: transnational innovation ecosystems, universities' societal engagement, international relations (EU and China), Helix models of innovation, institutional theory, social network theory, social network analysis, professional social matching, ML, and KR and R. Our long-term goal is to design an AI-based system that can predict and match potential university and industry collaborators in transnational contexts, particularly matching European industrial firms with potential Chinese partner firms through their common connections to EU–China university cooperation, as demonstrated in the first two layers of boxes in Figure 5. The users of the system will be European SMEs. The users are expected to input their own professional network, including their collaborations with European university actors, on a voluntary basis, to the system to keep the database growing. Meanwhile the system will reward the users with suggested optimal industrial partners from China as well as the information concerning U–I co-innovation networks in between. Behind the user interface is the ML-based matching system. Along the lines in the second layer box, the dark grey rectangular boxes indicate examples of open data sources, used for ML.

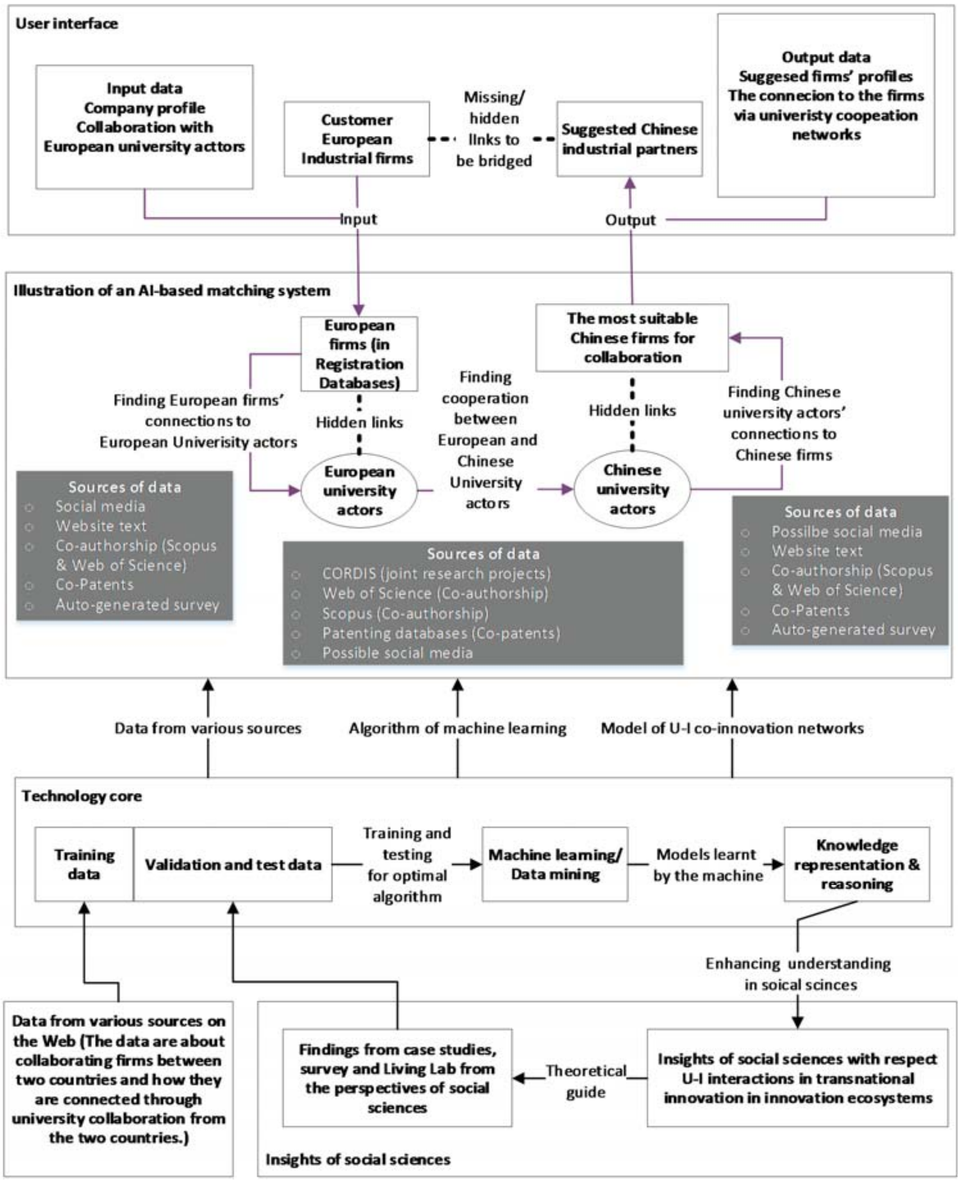

Figure 5. Illustration of an artificial intelligence (AI)-based system for building transnational university and industry (U–I) co-innovation networks.

The core technologies are ML and KR and R (demonstrated in the third layer boxes in Figure 5). To train the computer to make autonomous prediction, training data from various sources, such as those examples in the grey boxes, will be gathered. Here the data are about existing links between TIC and TUC.

The integration of social sciences and AI is shown in the third- and fourth-layer boxes in Figure 5. The insights of social sciences theories and studies, as mentioned early in the paper, will be used for guiding empirical research on TIC and TUC synergy building. The possible methods are case studies, Living Lab and survey. The findings (data) of the research will be the sources of validation and test data, which is important for improving and optimizing the ML algorithm. On the other hand, the models developed by the AI system will help enhance understandings of TIC and TUC interactions in social science studies.

While Figure 5 illustrates an overall view of our approach, we try to give a bit more details of the AI-based methods (or the technology core in the third layer box). Our modelling and prediction of TIC and TUC co-innovation networks are on the organizational level, though our data mining will process the data of individual organizational members. Our proposed approach is composed of three phases: (1) Data Preparation, (2) Data Analysis, and (3) TIC and TUC matching. The latter is the step wherein, based on the reasoning of semantic information, the hidden cooperation links are inferred. This section describes each phase in order to provide understanding on the interrelated techniques and parts of the approach, which is depicted in Figure 6.

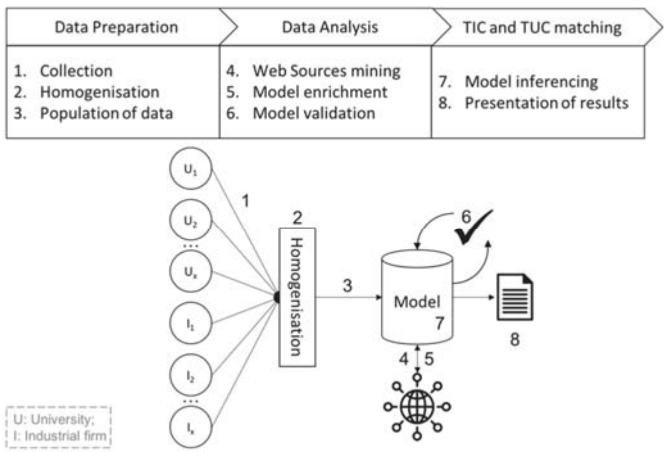

Figure 6. Different phases of the approach for inferencing transnational industry cooperation (TIC) and transnational university cooperation (TUC) matching.

Data Preparation is the first step in understanding the data and transforming it into interpretable information. In fact, data preparation is divided into three subtasks: collection, homogenization and population of data. First, the data are collected from both open source data and different partners who are willing to cooperate within the network on a voluntary basis. To achieve this, future partners will have access to a platform wherein they can fill out profile information. This information includes aspects such as name and type of organization, interests, availability of human resources and so on. Additionally, existing databases (e.g., the CORDIS EU project databases, Web of Science) and other web resources, such as provided website links and social media, are also added for further data mining. ML-based techniques will be used to mine data from web links, aiming to finding patterns that can be later used to match information to other partners in the network. Second, the data are homogenized in the platform format, which in turn is compatible with the semantic model to be populated. In this context, as the semantic model is built within ontologies, the selected format is the Ontology Web Language (OWL), which can be queried by other parts of the platform within SPARQL Protocol and RDF Query Language (SPARQL) queries. On top of the OWL statement, the model includes a set of semantic rules that derive from inferences at the third stage of the proposed approach.

Once the data are prepared and thus included in the semantic model, the data are analyzed in the Data Analysis phase. There are two types of analysis in this phase. First, as stated previously, web sources are mined in order to find common patterns. Found patterns permit the creation of new statements that will extend the ontology. Furthermore, the semantic model consistency is validated within a semantic reasoner. In this approach, the Pellet reasoner is used for such a validation.

Finally, once the model is populated and validated, the third stage regards finding the potential cooperation between parties within the TIC and TUC matching phase. This is achieved within the inference of ontological descriptions enriched within semantic rules. More precisely, Semantic Web Rule Language (SWRL) rules are used, as they are compatible with Resource Description Framework (RDF)-based models and hence OWL ontologies. The finding of implicit relations between ontological resources within similar interaction of technologies and languages have been demonstrated on previous research work by the authors [125,126].

One of the benefits of this approach is that the described stages are automatically executed with only the need for the profiles of university and industry actors. The platform engines manage the tasks regarding the corresponding data and present the results, i.e., the potential cooperation, to the collaborative partnerships. This is provided to the platform owner as a report to be later shared with the platform users.

5.2. Potential to Answer the Research Questions Using the Transdisciplinary Approach

Once our proposed approach has been developed, it will better answer the three research questions raised at the outset of the paper. To make clear how our approach advances state-of-the-art research, we contrast the potential contributions of our proposed approach to the research questions and the limitations of existing literature (Table 1).

Table 1. Answers to research questions by existing literature and our proposed approach.

Research Questions	Limitations of Existing Literature	Potential Contributions Offered by Our Proposed Approach
Why should TIC and TUC be looked at as synergetic entities?	The synergies between TIC and TUC are hypothetical. Scarce data are available for empirical exploration.	A large scale of transnational U–I co-innovation networks will be detected and developed. This will enable deep empirical investigations and even big data analyses.
How can the synergy building be theoretically elucidated?	The theories, to varying extents, elucidate the mechanisms underlying the synergy building between obvious actors crossing sectors/communities, but mainly in a domestic context. The relations between the actors are one to one (or one to more).	The AI algorithms will be based on integrating several social science theories, which provide theoretical foundations concerning developing collaborative relations (networks) between unobvious (cross-sectoral) actors in a transnational context. Our frameworks address the relations between different pairs of collaborators.
How can the synergy building be methodologically realized?	SNA: lacks efficiency in exploring hidden/missing links. Professional social matching (PSM): not for matching in a cross-sectoral and transnational context. AI technologies: no suitable algorithms and training data ready to use.	A comprehensive method will be developed by integrating social science studies and AI in the context of transnational innovation ecosystems. It is not only for detecting potential collaborators and links between them, but also for building the networks.

6. Conclusions

This paper has demonstrated how social sciences and AI could be integrated to develop a transdisciplinary approach to TIC and TUC synergy building, thus contributing to the knowledge pool in which studies on TIC and TUC have been separately reported in spite of a growing awareness on necessary of synergy building between TIC and TUC. Specifically, the originality of our research lies in four aspects.

First, while the research on TIC and TUC synergy building is almost an uncharted field, our research maps a landscape of the research area with identification of specific research gaps through extensive analysis of relevant literature. Our efforts are around discussions on how existing research may offer useful insights and have limits in answering three questions: Why should TIC and TUC be looked at as synergetic entities? How can the synergy building be theoretically elucidated? How can the synergy building be methodologically realized? The diagnose of advantages and weaknesses of state-of-the-art research in the field not only serves as clear point of departure of our research on TIC and TUC synergy building, but also helps guide more scholars to plunge into the field.

Second, we propose a transdisciplinary approach to TIC and TUC synergy building by integrating insights of social sciences, such as Helix Model of innovation, institutional theory and social network theory, and AI, such as ML and KR and R. While the insights from social sciences have the potential to answer the question of why TIC and TUC should be regarded as synergetic entities, AI technologies can help answer the question of how such synergies can be realized. Current methods using AI (i.e., ML) in social science research tend towards two extremes: they are used either for verifying assumptions about human intelligence or for independent prediction, thus tending to replace human intelligence. We try to integrate between social-science-based theoretical modelling and data-based computational modelling, particularly regarding the understanding of TIC–TUC interactions. Empirical findings guided by social sciences theories will help improve ML algorithm by providing validation and test data. The models learnt by machine will be useful input for advancing understanding of TIC and TUC synergy building in social sciences studies.

Third, our proposed approach will specifically identify/predict hidden/missing connections between actors in TIC and TUC co-innovation networks by analyzing unstructured data from various sources, such as public databases (e.g., research projects, co-publications, patents), website text (on cooperation activities) and auto-generated survey data. In doing so, on one hand we try to advance current social network analyses, which mainly map out anticipated networks by processing classified data [107]. On the other hand, we will open new horizons for studies on professional social matching [34] from both cross-sectoral and transnational perspectives.

Finally, our approach of AI-based matching system will help realize the potential role of university for institutional change and trust building, which are important to the sustainable dimension of innovation ecosystem development.

Nevertheless, our paper is primarily on the conceptual level discussions. Despite promising potential of our approach, it must be first tested and verified with sample data. This will be our next research task. It should also be noted that matching TIC and TUC, e.g., in the EU and China context, is just the first step to building EU–China transnational co-innovation networks. To achieve full synergy of the networks, there are also other important issues that need to be deeply explored, such as research and innovation policies, entrepreneurship, knowledge management, intellectual property rights, and inter-cultural communications. This will indeed open a new area of multidisciplinary research. Studying the TIC and TUC synergy building in the EU and China context also propels an urgent demand for closer communication between two separate research communities, namely international researchers and Chinese researchers both conducting research on the topic [127].

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Developing Joint R&D Institutes between Chinese Universities and International Enterprises in China's Innovation System: A Case at Tsinghua University

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Abstract: This paper examines the role of joint R&D institutes co-established by Chinese research universities and international enterprises. Guided by an analytical framework of institutional logics in the evolution of the Triple Helix model, this study aims to explore the institutionalization process of a joint R&D institute in the contexts of global and Chinese innovation systems; further, it analyzes which mingling institutional logics, respectively carried by a Chinese research university and an international enterprise, affect the collaboration between both parties moving from informal R&D collaboration toward an institutionalized organization. The case study method enabled the author to understand the complexity of the interlacing of international and national actors with regards to the joint R&D institutes. The contribution of the study to the existing literature is two-fold: on the conceptual front, it advances theoretical understandings of the interactions of institutional logics which result in varied patterns of joint R&D institute in a national context with transnational factors; on the empirical front, it examines the evolutionary path of a joint R&D institute established by a Chinese research university and an international enterprise.

Keywords: joint R&D institute; institutional logics; China's innovation system; China's transnational Triple Helix linkages; Chinese research university

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1. Introduction

In the contemporary era of R&D globalization, when knowledge, technology and human resources are becoming globally and geographically distributed, many research-intensive universities are increasingly engaged in R&D partnerships with international enterprises [1]. Joint R&D institutes are an important form of partnership taking place between research universities and international enterprises [2,3].

The key term of this study, joint R&D institute, originates from the broadly defined concept of cooperative research center [4–9]. The term "joint R&D institute" is used alternatively in this study in order to highlight the contextual relevance of Chinese research universities, as the names of China's university-based cooperative research centers always start with "joint" (*Lian He* in Chinese) Joint R&D institute in this paper is defined as:

An organization or unit, jointly established by a research university and an international enterprise, that have officially registered in the university's research management department with explicit missions to promote, directly or indirectly, cross-sector and cross-border collaboration, knowledge and technology transfer, and ultimately innovation [6,10].

In this study, the joint R&D institutes refer to the cooperative research centers jointly established by Chinese research universities and international enterprises. They share the three common features with the cooperative research centers, which are identified by Boardman and Gray (2010: 451): (1) engagement in research, (2) exhibition of organizational formality, and (3) promotion of organizational and cross-sector collaboration and transfer. In this study, the above-mentioned "larger organization" refers to the joint R&D institute's affiliated university. The joint R&D institutes' mandates, operations and activities reflect the interests of both their affiliated universities and their external international sponsors. Moreover, their organizational formalities are more flexible than departmental structures and can be adjusted to increase the universities' adaptations and responsiveness to the demands of the external community [11,12].

Since the mid-1990s, when an increasing number of international enterprises started to move better paid and more brain-intensive labor to China, Chinese research universities have become the primary R&D partners for these enterprises [13–15], and joint R&D institutes have become one of their most important forms of partnership [16–19]. As of 2016, international enterprises had established more than 1800 R&D institutes in China [20]. According to statistics from the Ministry of Education of China, the key universities directly under the supervision of the Ministry of Education have close collaborations with more than 1100 enterprises from more than 100 countries around the world [21].

What, then, are the attractions of China, and the Chinese research universities, for those international enterprises? Wang et al. [22] perceived R&D cooperation as a kind of transaction. The major incentives for international enterprises are pressure from market competition and cost saving. Universities provide knowledge and cultural products as well as human resources to enterprises, while enterprises can supply universities with funds, equipment, and information about market needs for talents. Xue (2006) [23] provided a similar opinion: owing to the favorable research platforms offered by joint R&D institutes, international enterprises can easily synergize internal and external R&D resources, lower their development costs through avoiding transaction costs, reduce the risk of project failure due to better interaction, and acquire promising graduates from Chinese universities.

Cong and Xue [24] discussed the international enterprises' strategic planning from the perspective of integrated innovation, which means integrating, coordinating and optimizing interrelated, interdependent and interactive innovation elements to achieve the specific purpose of efficient innovation. The reason why international enterprises have decided to cooperate with Chinese research universities in the rapidly growing technological field is to reduce the risk brought by remarkable technological change. They want to trace the new direction of universities' basic and applied research, and to be prepared to effectively integrate newly developed technologies with existing ones. Therefore, when R&D cooperation involves technological exploration that is closely bound up with the enterprises' development strategies, the enterprises will attach much attention to process and result management.

He [25] believes that, besides acting as the nodes of international enterprises' global R&D expansion, joint R&D institutes can also become involved in enhancing the universities' independent innovation capacity and disciplinary development level, as well as serving as an interface for technological cooperation and knowledge exchange between universities and international enterprises.

Besides the intentional initiatives undertaken by international enterprises, behind the intensity of R&D partnerships lies the Chinese government's "invisible hand" [26]. China's prioritization of innovation since the second half of the 1990s, and the country's desire to acquire knowledge and technology, have provided important opportunities and vehicles for technology-intensive international enterprises to exploit their innovation activities in China [18,27,28]. Specifically, these include China's rapidly rising R&D expenditure, a larger and higher-quality talent pool, comparatively low-cost researchers, and an impressively growing number of scientific publications and patents [18,29]. When discussing the "invisible hand", Xue (2006) [23] stated that support from the Chinese government, in terms of policies and public funding, has been important for promoting joint R&D activities.

Joint R&D institutes are positioned as the most mature form of R&D partnership between Chinese research universities and international enterprises [19,21]. Li and Li [19] classified the forms of R&D collaboration into project commission, joint development, joint talent training, and joint R&D institutes. Huang [21] also made such a classification in terms of development stages: personnel exchange and academic visits, international academic conferences, joint research, joint research programs, and joint R&D institutes.

When enterprises and universities seek R&D partners then the joint R&D institutes, as long-term cooperative research platforms, should be established based on a strong complementarity of advantages [30,31]. Specifically, Gugler and Michel [32] argued that these partnerships should follow "4C" principles: complementary ability, cooperative culture, compatible objectives, and commensurate risks. When choosing locations, international enterprises prefer major cities with a strong presence of international investors, and universities with distinct disciplinary advantages and strong R&D capacities; the enterprise side should have a corresponding capacity for technological development, applied research, and technology transfer [31].

With regards to the adoption of cooperative modes, Wright et al. [33] classified the activities of joint R&D institutes into three stages: in the first stage of technological invention, a joint development model should be created; in the second stage of technological adaptation to the market, entrusted development can be the cooperative model; and in the third stage of technological diffusion, universities should provide advisory services to industries. According to Mowery and Sampat [34], entrusted development is a more important model than patent licensing and technology transfer in joint R&D activities.

Empirical investigations have revealed problems in the R&D partnerships in joint R&D institutes. Some studies have recognized the unequal status between Chinese universities and international enterprises as R&D partners. The international enterprises often take a dominant position in intellectual property right (IPR) ownership distribution [35], R&D orientation [36], and institutional management [37,38]. Some IPRs involving core technology are exclusively monopolized by international enterprises [39]. The unequal situation often reflects which side is the funding provider and unequal R&D strength, although the advantageous R&D strength of international enterprises also has a positive impact on the universities' R&D improvement [17].

However, a gap in R&D experience between partners [40], as well as skills for knowledge and technology application and innovation, can reduce the efficiency of technology and knowledge spillover [41]. Moreover, a lack of communication skills and channels has been identified. First, this problem has impeded the ability of university R&D management staff to obtain R&D management experience [42]; second, this may lead to deficiencies in prior agreements [40]; third, when misunderstandings or disputes take place within the partnerships, the lack of resolution mechanisms may result in obstruction of technology spillover [43].

Despite all these problems, the positive effects of R&D cooperation on Chinese universities have also been remarkable in terms of financial support and upgrades to R&D strength [44]; in particular, R&D cooperation has helped university researchers better understand the trends of large international enterprises' product and technology innovation in China. In addition, it can expand the university researchers' forward-looking and cutting-edge views in the field, which can better match the market's orientation [45].

As discussed above, establishing joint R&D institutes is really an emerging and flourishing phenomenon in China, and there is a general research challenge on the organizational analysis of such kinds of organizations. Nevertheless, the existing literature points out that the nature of joint R&D institutes between Chinese universities and international enterprises is concerned with a mix between Chinese and Western ways of organizing things. The organizing principles can be understood as institutional logics, which are "the shared conceptual and normative frameworks that provide guidelines for the behavior of field participants" [46] (p. 8). The literature also implies that specific features of joint R&D institutes and challenges in running such institutes are related to the nature. However, few studies have provided theoretical accounts of the nature of mixing logics of underlying joint R&D institutes, particularly in explaining how the mixed institutional logics have affected the development of the joint R&D institutes.

Related to the lack of theoretical understandings of joint R&D institutes, another gap is that the research on joint R&D institutes focuses much on issues within the organizational boundaries of joint R&D institutes, with little attention to the contexts in which the joint R&D institutes are embedded. As suggested by Cai et al. [47], the contexts involved in transnational university and industry collaboration can be understood as transnational innovation eco-systems. As one of the rare studies taking a macroscopic and systemic point of view when researching joint R&D institutes, Xue and Wang [45] argue that joint R&D institutes have acted as the nodes in the transnational innovation systems. These joint R&D institutes represent a new type of actor in China's innovation system, which has made the national boundary of the system vaguer. Their study not only confirms that a fundamental characteristic of joint R&D institutes is a hybrid of institutional logics but also implies that multiple institutional logics in the joint R&D institutes may derive from system levels of logics of both China and forcing countries, from which the collaborating enterprises come. However, there is no ready framework for understanding the influences of the system logics on the development of joint R&D institutes.

To bridge the gaps, this paper aims to build an analytical framework to understand the development or institutionalization of joint R&D institutes and apply the framework in an empirical case of Tsinghua University's collaboration with an international enterprise in developing a joint R&D institute. Meyer and Rowan [48] (p. 341) define institutionalization as a process "by which social processes, obligations, or actualities, come to take on a rule-like status in social thought and action". This paper seeks to probe what specific features of institutionalization raise collaboration from an informal international R&D partnership to a joint R&D institute, and what kinds of supportive environments lead to the development.

The framework used in this study is based on Cai [49,50] who used an institutional logics perspective to interpret the evolution of the Triple Helix model at the system level. The framework is relevant to this research for two reasons. First, the joint R&D institutes to be discussed in this paper act as hybrid organizations actively operating at the interfaces between the central government, research universities, and international enterprises [26,49,51]. Second, the institutional logics perspective provides an analytical tool to explain the outcome of a process with a certain length of time and to understand the influences of broader social and cultural norms on the cognition and behavior of individuals and organizations [52]. However, since Cai's framework itself is on the analysis on the system level, it will be revised for the use in organizational level analysis.

A joint R&D institute established by Tsinghua University (Tsinghua) and the United Technologies Corporation (UTC), i.e., the Tsinghua-UTC Research Institute for Integrated Building Energy, Safety and Control Systems, was adopted as the case in this research. UTC is an American multinational conglomerate. It researches, develops, and manufactures high-technology products such as aircraft engines, helicopters, HVAC, fuel cells, elevators and escalators, fire and security products, building systems, and industrial products, among others. UTC is also a large military contractor, producing missile systems and military helicopters, most notably the UH-60 Black Hawk helicopter. (https://en.wikipedia.org/wiki/United_Technologies. (Accessed on 10 November 2019)). Based on a review of the relevant academic literature, the major data source chosen was semi-structured and in-depth interviews (conducted during the periods of 2013–2014, and 2018; N = 15). The interviewees included researchers and administrative staff of the case institute, the university-level administrative staff of Tsinghua (who were responsible for university-industry cooperation or international cooperation), and administrative staff of UTC (who were taking care of university-industry collaboration).

Specifically, this paper seeks to probe the research question: what mingling institutional logics respectively carried by Tsinghua University and the UTC affect the collaboration between both parties moving from informal collaboration toward an institutionalized organization? Based on the research findings, the paper will solicit recommendations to policymakers and practitioners involved in joint R&D institutes between Chinese universities and international enterprises.

The contribution of the study to the existing literature is two-fold: on the conceptual front, it advances theoretical understandings of the interactions of institutional logics which result in varied patterns of joint R&D institutes in a national context with transnational factors; on the empirical front, it examines the evolutionary path of a joint R&D institute established by a flagship Chinese research university and an international enterprise.

2. Methodology and Case Selection

A case study stood out as the method of choice for this study [53,54]. Firstly, the selected method enabled the author to understand the complexity of the interlacing of international and national actors with regards to the joint R&D institutes; secondly, it enabled the author to understand the institutional environment and contextual relevance of the joint R&D institutes operating in China's transnational Triple Helix linkages and in China's innovation system.

The case of the Tsinghua-United Technology Corporation Research Institute for Integrated Building Energy, Safety and Control Systems (the Tsinghua-UTC Center) was selected, taking account of the following criteria:

- It was a research institute officially affiliated with Tsinghua University, rather than merely being located on the campus [55];
- It was a joint R&D institute co-established by Tsinghua University and an international enterprise;
- It was semi-autonomous from a traditional disciplinary department (an optional criterion) [56];
- The researchers of the institute were from more than one disciplinary department, and it conducted interdisciplinary research (also an optional criterion) [6,57].

The rationales for selecting the case of the Tsinghua-UTC Center affiliated with Tsinghua University were as follows:

As a flagship Chinese research university, Tsinghua bears the brunt of the responsibility for achieving the objectives of governmental higher education or science and technology programs [58]. On the other hand, it has been given priority to enjoy intensive governmental R&D investment. Geographically, socially, and politically, Tsinghua has the closest connections with the central government, in particular with the Ministry of Education (MOE) and the Ministry of Science and Technology (MOST) [59].

The abundant financial and human R&D resources possessed by research universities like Tsinghua have been a significant precondition for large international enterprises to co-establish joint R&D institutes with them [60]. Tsinghua has been among the most popularly targeted Chinese research universities when international enterprises consider R&D partnerships in China (Interview THU UA 2).

Moreover, Tsinghua possesses high-quality multi-disciplinary researchers. A majority of them have overseas education or working experience. This has guaranteed the human resources of the international and interdisciplinary joint R&D institutes [61]. The researchers of Tsinghua have always taken the lead in various forms of international R&D cooperation and university–industry partnerships [59].

The case study of the Tsinghua-UTC Center was conducted by the author in 2013–14 on the basis of a literature review and fieldwork. In addition to publicly accessible information, including the official websites of Tsinghua, the Ministry of Education (MOE), the Ministry of Science and Technology (MOST), and the National Bureau of Statistics of China, and the brochure of the Tsinghua-UTC Center, semi-structured interviews were the major source of evidence in the study.

The participants in the study can be categorized as follows:

(1) Group One: members of the Tsinghua-UTC Center. Four Tsinghua researchers (one professor, one associate professor, one post-doctoral fellow, and one postgraduate research student); one marketing staff member from the UTC; and one administrative staff member of the Center;
(2) Group Two: three university-level administrative staff members of Tsinghua, who oversaw the university–industry cooperation, international cooperation, and disciplinary planning;
(3) Group Three: one government official from the MOE and two from the MOST;

(4) Group Four: five external observers, scholars who were specialized in the fields of the internationalization of higher education, university–industry linkage, Chinese higher education transformation, and Chinese higher education policy.

3. Analytical Framework

The fundamental assumption underlying the analytical framework to be developed in this paper for understanding the influences of mingling institutional logics at the system level for the development of joint R&D institutes is that the joint R&D institutes are in the contexts of mixing institutional logics in both China's innovation system and a global (Western) innovation system (as illustrated in Figure 1). Chinese universities carry the logics from China's innovation systems and the Chinese university's collaborating international enterprises and joint R&D institutes carry institutional logics from Global (Western) innovation systems. When analyzing the contextual influences on the evolution of joint R&D institutes, the following elements are needed: (1) a framework for analyzing institutional logics in innovation systems, (2) differences between disparate institutional logics in Global and China's innovation systems, and (3) a framework for understanding the evolution of joint R&D institutes. The three aspects are introduced in this section and then integrated into the analytical framework.

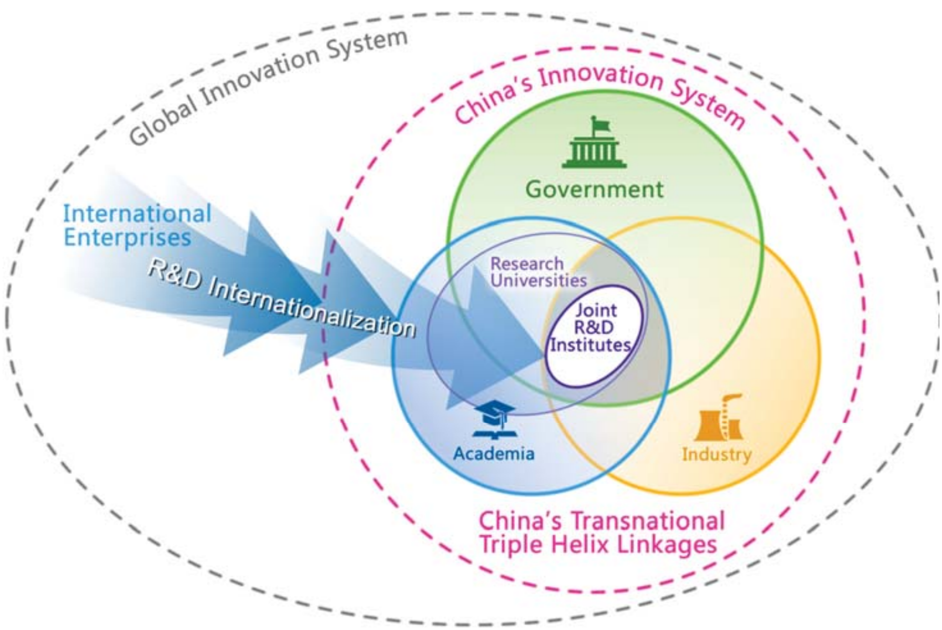

Figure 1. Joint R&D institutes in the context of global and China's innovation systems.

3.1. Institutional Logics in Innovation Systems

When understanding institutional logics in innovation systems, this study adopts Cai [49,50], who understands innovation systems from the perspective of Triple Helix Model, and identifies seven institutional logics aligned with an ideal Triple Helix model. The "ideal model", together with the "statist model" and the "laissez-fair model" were classified by Etzkowitz and Leydesdorff [62] as the three major types of Triple Helix models. In the statist model, the government encompasses university and industry, and decides the relationships between them; it is expected to take the lead in innovation initiatives and provide resources for these new projects. The laissez-faire model defines the three helices as different communication systems with strong borders dividing them and highly circumscribed relations among the spheres [49,63]. In the ideal model, in addition to its traditional function, each helix undertakes the roles of the others. Government devolves the role of regional and local innovation coordinator to the other two actors: i.e., industry engages in endogenous technological innovation and transfer, or industrial R&D laboratories emerge in universities; in response to the changes, universities not only play an innovative role in traditional basic research, but also in applied research, entrepreneurial training and community building [49,63,64]. This is said to be an ideal model which represents a global tendency in innovation systems [63].

Institutional logics can be generally understood as "the socially constructed, historical pattern of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality" [65] (p. 804). The institutional logics in certain contexts will explicitly affect the communication paradigms of different stakeholders, and determine prioritized problems and appropriate solutions [52].

Cai associates the seven institutional logics with four stages of institutionalization of Triple Helix development [49,50,66] (Table 1). This framework can be used for comparing institutional logics differences between Chinese and Western innovation systems.

Table 1. Institutional logics in the evolution of the Triple Helix model.

Stages of Development	Major Triple Helix Activities	Favorable Institutional Logics
Stage 1 **Realization of the needs**	Realizing the importance of entering a reciprocal relationship between university, industry and government	Shared beliefs on knowledge as a key to economic growth
Stage 2 **Intra-organizational transformation**	Taking the role of the other	Market orientation Process management
Stage 3 **Interactions between organizations in the three sectors**	Growing and innovating through cooperation with others Generating hybrid organization	Effective IPR Protection system Civil society
Stage 4 **Institutionalization of the Triple Helix model**	Feedback loops between policy-makers and participants Institutionalized norms of "entrepreneurial university", "knowledge-based formation and growth" and "innovation state" [26].	Competitive market Democratic policymaking

Source: [49,50,66,67].

In Stage 1 of the "ideal" model, the belief that the logic of technology advancement/innovation is the key to economic growth is shared by government, industry and university. In Stage 2, the logics of market orientation and process management will facilitate intra-organizational transformation in the process of 'taking the role of the other'. In Stage 3, The logics of IPR protection affect the efficiency of technology transfer from university to industry. In countries lacking a civil society, there often exists the statist model of Triple Helix, in which the state takes overall coordination responsibility and thus provides only a limited source of ideas and initiatives [68] (p. 62). In Stage 4 of the "ideal" Western model, the logics of competitive market and democratic policymaking can realize the best choices to engage in tripartite interactions, and eventually institutionalize the optimum model in the Western context [50] (p. 18).

3.2. Chinese Triple Helix System

The Triple Helix model in China was interpreted by Zhou [69] as a "government-pulled Triple Helix model": the state plays a central role in the innovation processes; the R&D resources are mostly derived from the government; universities and industries may lose initiative and flexibility in innovation; university–industry joint R&D projects tend to be "shows" for the government. Given such a context, China's Triple Helix model had long been categorized in the statist group [63,64,70]. Despite this common belief, a statist model is not the only one pertinent to China's national innovation system, given China's immensity and diversity [67]. The situation has been changing over the past two decades, and a transitional tendency from a statist to an ideal model has been acknowledged in the Chinese case.

Recent studies by Cai and Liu [71,72] challenge the conventional view of seeing China as a statist Triple Helix model. They found a variety of Triple Helix models in Chinese regional innovation systems by taking into account of multiple layers of government, e.g., central government, municipal government and district government, in a Triple Helix analysis. In the case of Tongji University Creative Cluster, they found an effective Triple Helix model, combining both bottom-up initiatives in the initial stage and top-down coordination in later developments [71].

The transition of China's Triple Helix model was demonstrated by an OECD study completed in 2008 [73]. The core ideas of this transition are: the governmental batons have started to become invisible; the spiral of academia works more closely with industries; in particular, the government has become increasingly supportive of the enhanced role of universities in assuming a "third mission" in addition to their traditional functions of teaching and research [29,67,73].

Overlapping institutional spheres, the main element of the ideal model, have emerged, which have gradually become the core of various innovation systems due to the advantages of their networked infrastructures in terms of social benefits, economic efficiencies, and sustainability [26,51,64,74]. They have been expected to create knowledge spillover and to contribute to the capacity of innovation systems [26,51,75].

Joint R&D institutes, as hybrid organizations, are incubated in the knowledge infrastructure of these overlapping institutional spheres. Their flourishing in Chinese research universities, from this angle, can certify the transition of China's Triple Helix model.

3.3. The Collision of Western and Chinese Institutional Logics

It has been understood that the ideal Triple Helix model has been advanced from the Western experience of economics, and it is called "ideal" as it has been proven by a number of empirical cases in Western societies that the overlapping and interdependency between the three sectors provides favorable conditions for innovation. The ideal model was initially developed and has been institutionalized in Western societies, thus the institutional logics that facilitate the institutionalization process are Western-oriented [49,76–78]. When the ideal Western Triple Helix model is applied in China's innovation system, a non-Western context, the logics associated with the ideal model are likely to be imported as well [50].

However, there is a lack of theoretical consideration and empirical evidence on whether the ideal Triple Helix model is ideal for China, as the local institutional logics of the Triple Helix model in China are different from those in the West [49]. Moreover, the institutional logics of non-Western Triple Helix models, such as the China-specific one, may result in more obstacles to a favorable innovation environment compared to the institutional logics of the ideal model in Western countries [67]. The establishment and evolution of joint R&D institutes by Chinese research universities and their "Western industrial partners" may result in collisions between Chinese and Western institutional logics. Taking account of the China-specific social relevance and settings, the collisions have the potential to interpret the challenges and dynamics of developing different models of Triple Helix linkages in the context of China's innovation system.

3.4. Institutionalization of Joint R&D Institutes

Although in Cai's [49,50] analytical framework the institutional Triple Helix model is on the innovation system level, the evolution of an innovative organizational model of joint R&D institutes can also be understood as a process of institutionalization [79]. When identifying the four stages of Triple Helix development, Cai [50] is based on the common notions of the stages of the institutionalization process, basically including three stages: "first, organizational actors realize there is a need for change; then they initiate organizational changes; and finally the changes either become institutionalized or are terminated" [50] (p. 306). The broader social and cultural norms of innovation systems that make changes to organizational patterns of joint R&D institutes and persist in time belong in the institutional order [80]. This study attempts to probe the outcome of an evolutionary process which is subject to the broader conditions of certain contexts rather than focusing exclusively on organizational features of joint R&D institutes. It is thus justified to choose the institutional perspective for this study.

3.5. Integrated Analytical Framework

The establishment and evolution of joint R&D institutes co-established by Chinese research universities and their "Western industrial partners" may result in collisions between Chinese and Western institutional logics. Thus, we need an integrated framework to link the macro and micro level of analysis. Based on synthesising the theoretical insights discussed above, the following analytical framework is constructed in Table 2.

Table 2. Institutional evolution of joint R&D Institutes co-established by Chinese research universities and international enterprises.

Stages of Development	Description of the Stage	Mingling Institutional Logics (Tensions vs. Reconciling)	Influences of Mixing Institutional Logics on the Development of Joint R&D Institutes
Stage 1 Realization of the needs	Chinese government, university, and international enterprise realize the needs for transformation and interaction	Rising awareness and common belief: *technology and knowledge innovation* is a key for sustainable economic growth Motivation and logics of the international enterprise: *knowledge innovation* and *market orientation*	The international exchanges deepened understanding and belief of the Chinese university in *technology and knowledge innovation* and thus facilitated the institutional evolution.
Stage 2 Intra-organizational transformation in the Chinese university	Joint R&D endeavors between Chinese universities and industries start to prosper University, industry and government "taking the role of the other" [68]	Logics of *market-oriented organizational cultures* and *process-oriented management culture* in technology innovation	The international enterprises' increasing approaching to Chinese research universities accelerated the government and university to perfect the corresponding institutional settings.
Stage 3 Interactions between Chinese university and international enterprise	Joint R&D institutes are created through interactions between organizations in the three sectors ("generating hybrid organization") The danger in "taking the role of the other"	An agreement based on the logic of *knowledge innovation* Disparity in thinking paradigms: Logics of *technology innovation and market orientation* A salient impact of the logic of *process management* The danger in "taking the role of the other": logics of *market orientation and process management* Inadequate regulations and inexperience: logic of *IPR protection* The absent logic of *civil society*	Service and "catch-up" mentalities of Chinese university resulted in the danger in "taking the role of the other". The awareness of Chinese government and universities about IPR protection was raised in the process of cooperating with international industrial partners. The potential of joint R&D institutes to create functional mechanisms that can coordinate between top-down control and bottom-up initiatives.
Stage 4 Institutionalization of joint R&D institute	Joint R&D institutes cause a crowding-out effect [16] between international and Chinese enterprises	Logics of *the market competition environment* The absent logic of *democracy in policymaking*	The joint R&D institutes have the potential to raise the logic of market competition in China's Triple Helix linkages.

4. Results and Discussion

The results of this paper examine the institutional development and contextual relevance of a joint R&D institute co-established by a Chinese research university and an international enterprise. The discussions return to the research question posed in the introduction section of the paper and link the findings from the case back to the analytical framework of Cai's [62,69] institutional orders in the evolution of Triple Helix models. Which mingling institutional logics, respectively carried by Tsinghua

University and the UTC, affect the collaboration between both parties moving from informal R&D collaboration toward an institutionalized organization?

4.1. Stage 1: Realization of the Needs

4.1.1. Common Belief: Logics of Technology and Knowledge Innovation

In the first stage, it has been commonly acknowledged that single organizational sectors alone can no longer respond to changes and uncertainties unless they cooperate with each other [49]. In the circumstances of this study, when China tried to deepen its integration into the global society, we can perceive a rising awareness in universities, industry and government that technology and knowledge innovation is key for sustainable economic growth. This common belief started to grow and enabled the "Triple Helix impetus" [69].

To motivate the universities and enterprises to cooperate with each other, the Chinese government provided regulatory mandates. In 1996, the law on "*Promoting the Transformation of Scientific and Technological Achievements*" was issued to encourage joint R&D activities. In 1999, the Ministry of Education launched the "*Action Scheme for Invigorating Education in the 21st Century*". Within this scheme, the "*Project to Stimulate the Industrialization of High-Technology Industry in Universities*" was specifically implemented to develop joint R&D institutes in universities. The visible result in 2000 saw an over 200% increase in R&D centers from previous years [6]. China is turning to gain a stronger normative basis for developing the Triple Helix [50]. Both the normative and regulative initiatives lead to the second and the third stages of Triple Helix evolution.

4.1.2. The Motivation of UTC to Work with Tsinghua: Logics of Knowledge Innovation and Market Orientation

UTC has its own in-house research institute. Like most of the in-house research institutes of large enterprises, the UTC research institute is funded by the business units of UTC; the difference is that it supports the organic growth of UTC not only through technology innovation, but also it pays great attention to knowledge and process innovation. Some research fellows of the UTC research institute can go back to academia without an academic gap but possessing advantageous experience working closely with industry. Considering the knowledge innovation capacity of the UTC research institute, why did UTC still need a joint R&D institute with Tsinghua? It was the then-Director of the UTC research institute who made the decision to work with Tsinghua (Interview THU-UTC 05, 06).

First, UTC considered expanding its market in China. A university-based joint R&D institute could provide a breakthrough and a solid foundation. Tsinghua was strategically selected as a channel for UTC to get close to the Chinese government, as UTC knew of the governmental resources possessed by Tsinghua (Interview THU-UTC 05, 06). Second, the current tendency in industrial development required UTC to explore the pathway of system solutions in the new architecture of building control. The team of Professor Jiang Yi, from the School of Architecture at Tsinghua, was world-renowned in this field (Interview THU-UTC 05, 06). Third, a joint R&D institute at Tsinghua could provide high-quality but low-cost researchers. Moreover, research students engaging in joint R&D projects would become candidates for their talent pool. Some hidden motivations were revealed by a member of the Tsinghua-UTC Center, who was a representative of the UTC side:

> Actually, five million US dollars is not a big amount for UTC as a large international enterprise. The cost effectiveness of this venture is very high. It seems like UTC does not have concrete requirements for the center. This is a very smart strategy. The Tsinghua researchers can feel UTC's kindness and flexibility and they are pleased to work on high-quality projects. Moreover, UTC can win some prestige in China from partnering with Tsinghua. With the Center as a window, UTC has gained some added value: it has had opportunities to join Sino-US energy cooperation at the national level. Professor Jiang is a leader of one of the research themes, so UTC can take part in high-profile cooperation through the Tsinghua-UTC

> Center. Professor Jiang has also introduced UTC to governmental agencies including the Ministry of Construction and the MOST. It is crucial for UTC to expand its market shares in China. (Interview THU-UTC 04)

4.2. Stage 2: Intra-Organizational Transformation in the Chinese University

In the second stage, each organizational sector "takes the role of the other" (as secondary tasks), but they maintain their distinct identities and perform traditional roles (as primary tasks). In this stage, universities engage in industrial activities, enterprises further strengthen their R&D capacity, and governments also provide venture capital to help start new enterprises. The institutional logics underlining these changes are market-oriented organizational culture and process-oriented management culture in technology innovation [50].

In the case of Tsinghua, during the process of "taking the role of the other", the Triple Helix actors have respectively realized the need for engaging in each other's fields, but sometimes institutional conditions have not been ready [49].

The Tsinghua leadership took the pioneering initiative to establish the University–Industry Cooperation Committee (UICC) in early 1992, which was partly inspired by the Western experience of managing university–industry R&D cooperation. In addition, the joint R&D cooperation between Tsinghua and UTC started in 1995, among many other international joint endeavors. The international exchanges deepened understanding and belief of Chinese universities in technology and knowledge innovation and thus facilitated the institutional evolution.

As a leading science and technology university in China, Tsinghua's international R&D cooperation with industry is among the top in Chinese research universities, in terms of funding, disciplinary scale, and the qualifications of the international industrial partners [59]. More than 70 percent of Tsinghua's international R&D funds come from international enterprises. The primary pattern of international R&D cooperation with industry at Tsinghua is joint research projects. Most of the joint R&D institutes are established and sustained based on projects. The other two forms of international R&D cooperation with industry are: (1) university-based foundations set up by international enterprises and (2) licensed patents and know-how (Interview THU UA 2).

The business of Tsinghua's joint R&D institutes is related to three administrative departments: (1) the University–Industry Cooperation Committee (UICC); (2) the Overseas R&D Management Office (Overseas RDMO); and (3) the International Technology Transfer Center (ITTC) (http://www.kfb.tsinghua.edu.cn/qhw/index.htm (Accessed on 1 December 2019)).

The Tsinghua leaders have always been responsive to national tendencies. Since Xiaoping's call for accelerating economic reform and opening the door to the outside world during his publicized tour to southern provinces in early 1992, intra-organizational transformation has taken place, and organizations in university sectors have tended to be more market oriented [51]. In 1995, Tsinghua took a pioneering initiative among Chinese universities: it established the University–Industry Cooperation Committee (UICC), after then-President Wang Dazhong visited MIT. He was obviously inspired by the Western experience of managing university–industry R&D cooperation (Interview THU UA 2).

The organizational structure of the UICC is demonstrated in Figure 2:

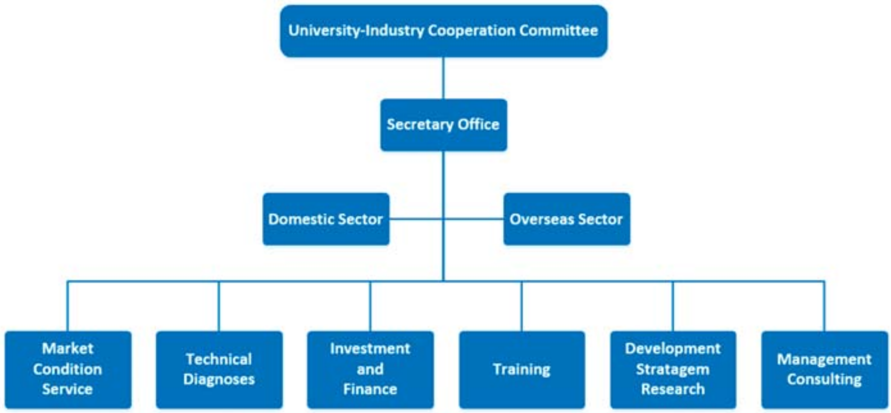

Figure 2. Organizational structure of UICC. Source: http://www.kfb.tsinghua.edu.cn/jgjs/index_jgjs.htm (Accessed on 1 December 2019). Translated and reorganized by the author.

The UICC serves as a platform connecting Tsinghua academia and enterprises. It functions like an enterprise club, accepting domestic and international enterprises as members. The enterprises need to pay an annual membership fee to get access to the events and meetings organized by the UICC. The UICC also helps the member enterprises organize job fairs and set up scholarships, and helps Tsinghua faculty members find industrial partners. Many joint R&D institutes at Tsinghua are incubated through the UICC's platform (Interview THU UA 02). The UICC serves as a market-oriented door to Tsinghua, as elaborated upon by a representative from an international enterprise member of the UICC:

> We are very happy to have such a channel to connect us with Tsinghua. If we need to approach Tsinghua professors and invite them to be consultants for our R&D activities, it is very difficult to find the right persons. All the Tsinghua teachers are extremely busy. The UICC will do their best to help us find the professors we are looking for or recommend other appropriate candidates. Other than that, if we want to visit any institutes of Tsinghua or find out information about Tsinghua's organizations, they can act as our connection. (Interview IDS01)

After the UICC opens the door for Tsinghua's potential R&D cooperation with international enterprises, the following step is official negotiation between Tsinghua and international industrial partners. This process is managed by another administrative department, the Overseas R&D Management Office (Overseas RDMO). The Overseas RDMO manages legal issues, including IPR, contract review, and mid-term and final evaluation. It works closely with the UICC, and has an obvious marketing function. At the university level, the joint R&D institutes are managed by the Overseas RDMO (Interview THU UA 02).

The third administrative department related to the business of the joint R&D institutes of Tsinghua is the International Technology Transfer Center (ITTC). Different from the other two departments, the ITTC was established and funded by the government (Interview THU UA 01). In 2001, Tsinghua was authorized by the MOE and the former State Economic and Trade Commission to set up such a technology transfer institute together with five other science and engineering universities. Initiated by the government and integrated into Tsinghua's technology transfer system, the ITTC facilitates Chinese enterprises' international R&D cooperation, and provides channels for international technologies to be introduced to the Chinese market (International Technology Transfer Center. About us: Profile. Available online: http://www.ittc.com.cn/ittc/english/html/aboutus/profile.asp (accessed on 10 November 2019)). While the other five university technology transfer centers came across bottlenecks, the ITTC at Tsinghua runs well. Nevertheless, it also is facing new challenges and demands. As a solution, the Triple Helix sectors need even closer cooperation and interaction [64,81].

The institutional setting for R&D cooperation between Tsinghua and international enterprises is comparatively mature, although Tsinghua does not have stated strategy and regulation to encourage and regulate such international R&D cooperation. Tsinghua leadership expects that its researchers can take on a dominant role in initiating and sustaining international R&D partnerships, rather than always taking the role of serving the large international enterprises by solving their technical problems. Cooperative technical projects can make money, but they do little to create knowledge spillover and contribute to the innovative capacity of the university (Interview THU UA 01).

In addition to UICC, Overseas RDMO and ITTC are functional departments to accelerate and manage the university's engagement with international industrial activities. Together with the ITTC of Tsinghua, the government created technology transfer centers in another five universities, but only the Tsinghua ITTC runs smoothly. Nevertheless, the governmental initiative demonstrates the logics of the market at the state level as well as beliefs in technology innovation as a key to economic growth. On the other hand, the international enterprises' increasing approach to Chinese research universities accelerated the government and university to perfect the corresponding institutional settings.

4.3. Stage 3: Interactions between Chinese University and International Enterprise

The joint R&D cooperation between Tsinghua and UTC started in 1995. After 12 years of partnership, the Tsinghua-UTC Center was established in September 2007. It started with a five-year renewable contract. UTC decided to invest one million US dollars in the Center every year continuously for five years, and the contract was completed by the end of the second five-year term (Interview THU-UTC 05, 06).

4.3.1. The Agreement between Tsinghua and UTC: An Agreement Based on the Logic of Knowledge Innovation

UTC has its in-house research institute with a strong research capacity, and it was the logics of market orientation and process management that drove the UTC to approach Tsinghua: the government resources possessed by Tsinghua could help the UTC to expand its market in China. Moreover, Prof. Jiang's Tsinghua team was one of the top in the field. In the first five years, the UTC demonstrated high respect and patience for knowledge innovation and accumulation.

In the process of building up the partnership, the Tsinghua side was passive (Interview THU UA 01). The final agreement for establishing the joint R&D institute was a result of both sides' common pursuit of knowledge innovation. Mr. Robert Hobbs, the then-Director of the UTC research institute, sketched a blueprint for the joint venture to persuade Prof. Jiang. He promised sufficient space for knowledge innovation and no interruption from the UTC business units. It is rare for a for-profit industrial organization to make a promise not to request any concrete technology or product innovation from a partnership with a university. Prof. Jiang's Tsinghua team was fascinated by the aim of exploring the new generation of building control systems, and Prof. Jiang assumed the directorship of the Center in the end (Interview THU-UTC 08).

The orientation of the Centre to knowledge innovation amazed some Tsinghua researchers, as described by one of them:

> I felt a bit shocked when I joined the Center. I feel that what the enterprises undertake should be closely related to products, and profit is usually the primary goal of enterprises. However, what the enterprise (UTC) proposed is even more forward-looking than the university (Tsinghua). (Interview THU-UTC 08)

4.3.2. Disparity in Thinking Paradigms: Logics of Technology Innovation and Market Orientation

Even if Tsinghua and UTC agreed that the research orientation of the Center was forward-looking, their thinking paradigms were disparate: academics are excited about discovering or creating an innovative research field that deserves long-time investigation, while industrial people pay more attention to profit generation. Moreover, they may understand a term from different perspectives, as illustrated by a Tsinghua researcher: "At the beginning, we thought the 'cost' they talked about was an economic term. Actually, it implies a more generalized concept, which also includes something of a technological perspective." (Interview THU-UTC 08). The divergence caused difficulty in collaboration, but their interactions also created sparks of innovation.

Although disparity existed, the Tsinghua researchers appreciated that the joint R&D institute allowed them to work closely with UTC, which had been taking the lead in technology innovation in this field. The Tsinghua researchers valued the market-oriented culture in technology innovation brought by the partnership, as explained by a Tsinghua researcher of the Center:

> I feel that many of their suggestions are valuable. They advanced these ideas from the perspective of the industry. They stand at the frontiers of the market and can anticipate the development orientation of the market. When we study a technology or a system, we only focus on how advanced this system or technology is. Rather, they would analyze the cost of using this technology or working out this system. The questions they most frequently ask are: How much money should we input to work out this? What benefits can be obtained from doing this? (Interview THU-UTC 08)

4.3.3. A Salient Impact: The Logic of Process Management

The logic of process management brought by Tsinghua's substantive and sustainable partnership with UTC had a salient impact on the processes of knowledge production and technology innovation. It was also important for innovation efficiency [82].

In the first five years, the UTC side designated researchers and project managers from the UTC in-house research institute to be stationed at the Center, and they were paid by the UTC side. This situation was rare among Tsinghua's joint R&D institutes with enterprises. The UTC staff played multiple roles as project managers, coordinators and also researchers. They had to coordinate different actors from both Tsinghua and UTC. All the UTC staff were Chinese nationals and had relevant disciplinary backgrounds in the research field. They did not have difficulties working with the Tsinghua researchers in terms of professional knowledge (Interview THU-UTC 08).

Nevertheless, the UTC staff positioned themselves clearly, as they were paid by the UTC side. They informed Tsinghua of the ideas and decision of the UTC side, and they were also responsible for reporting the research progress to UTC. Sometimes, they had to reconcile conflicting opinions from different actors (Interview THU-UTC 08). UTC influenced the research process of the Center through these designated staff, as elaborated by one of them:

> We would listen to the ideas from both sides. We worked and discussed with the Tsinghua researchers, and we regularly had meetings with our headquarters in the US and listened to their views. Their ideas would affect our thinking. Then, our considerations would also impact the research of the Center. (Interview THU-UTC 08)

The logic of process management therefore infiltrated the Center through these continuous efforts and interactions. The research management style of the UTC staff was apparently different from that of the Tsinghua researchers: at the start of every project, the UTC staff would discuss and confirm the timetable with the Tsinghua research team; they would remind and push the research team before each time node, and the project could not go on to the next step unless the previous task had been verified, as UTC needed to control costs and progress (Interview THU-UTC 08).

On the other hand, the university researchers were comparatively flexible in managing research projects. They had their individual priority lists, and they were multi-tasking. In Chinese research universities, the reality is that industrial research projects are always outranked by governmental projects in the university professional promotion system. Moreover, the Tsinghua researchers were not administratively affiliated with the joint R&D institute, and they were from different disciplinary departments. It was quite challenging for the UTC staff to manage the research process. They tried very hard to build up a sense of belonging and team spirit at the Center, which proved to be effective (Interview THU-UTC 07, 08).

In addition to regular project meetings, a series of formal and casual activities to increase cohesive forces were organized. When necessary, the UTC staff also talked with the researchers individually. By the end of the first five years, most of the Tsinghua researchers identified themselves as "members" of the Center, rather than just "working for" the projects of the Center. They were enthusiastic about joining the research teams, and even proud of being members of the Center. This sense of identity is important for optimizing the institutional environment of joint R&D institutes, but managing this process is particularly difficult in the context of joint R&D institutes, and even harder if they conduct interdisciplinary research (Interview THU-UTC 07, 08).

Lang [83] believes that the success of technology innovation in the West is greatly attributed to the culture of process management. It was the culture of process management, among other so-called Western institutional logics, that had the most thorough impact on the Triple Helix relationship through an international joint R&D institute in two ways. Firstly, UTC, as a for-profit organization, is goal-oriented, without question. However, their patience for knowledge innovation and the trust they provided to the joint endeavor with Tsinghua made it a process-oriented adventure. Lang [83] believes that Chinese practices are more goal-oriented rather than process-oriented. The mentality of being pragmatic leads the Chinese to find shortcuts to outcomes and neglect process management. It is hard to conclude that being pragmatic originates from the country's inherent cultural constraints. Being pragmatic is strategically feasible and necessary in certain periods and conditions. Secondly, the Center embodied the standardized process management of knowledge production, which is a favorable institutional logic, especially in the process of academia and industry "taking the role of the other".

4.3.4. The Danger in "Taking the Role of the Other": Logics of Market Orientation and Process Management

The logics of market orientation and process management stand near the core element of the Triple Helix thesis—"taking the role of the other". One of the most important implications of this thesis is that when universities take on the role of industry, they must maintain their core missions of research and teaching, and "the third mission" must be adaptable to the primary ones [84]. Joint R&D institutes are one of the mechanisms that a research university employs to translate its research findings into use. Etzkowitz [84] warned of the danger of a university mining its innovation store and failing to replenish it because of dependence on short-term commercial gains (Ibid, p. 319). Joint R&D institutes, as hybrid organizations, are generated as a result of "taking the role of the other". Compared with other university research institutes, the university side of a joint R&D institute is more likely to run into the danger described by Etzkowitz [84].

In the second five years of the Center, Dr. David E. Parekh took over the role of Mr. Hobbs as director of the Center, which led to structural transformation of the joint R&D institute. Dr. Parekh felt that the Center had gone too far away from market needs, and it would take too long to see results. Short-term interests were more important than the benefits that might come from long-term knowledge innovation. As a result, the Center shifted to become pragmatic and goal-oriented. UTC asked the Center to generate R&D outputs that could be easily transferred into products by its business units (Interview THU-UTC 08).

The author of this study argues that, in the context of joint R&D institutes in China, the danger of "taking the role of the other" is not universities engaging with industry and becoming part of it, as Cai [23] stated; it is the service and "catch-up" mentalities of the Chinese university researchers, which can result in deviating from knowledge innovation. The service mentality is based on the university serving its industrial partners as funders and clients. This happened in the case of the

Tsinghua-UTC Center, especially in its second five-year term. Consequently, the Tsinghua researchers became outsourced researchers of UTC, identical to those at the UTC research institutes.

The "catch-up" mentality arises when universities partner with world-leading international enterprises like UTC. In the second five-year term, the UTC side progressively intervened in decision-making about the Center's research orientation, and the Tsinghua side tended to make concessions. One of the reasons for this is that the Tsinghua researchers believed that "they [UTC] stand at the frontiers of the market and can anticipate the development orientation of the market" (Interview THU-UTC 08). During the most recent decade, while China's flagship research universities like Tsinghua have grown to be acknowledged worldwide for their knowledge and technology innovation, they have gradually learnt how to get rid of the "catch-up" mentality and maintain equal dialogue with powerful international partners [58].

4.3.5. Inadequate Regulations and Inexperience: Logic of Intellectual Property Rights Protection

The Role of Tsinghua Administration

The Tsinghua-UTC Center had been regarded by the Tsinghua administration as a showcase for joint R&D institutes. As mentioned above, in 2014, the UTC research institute, as a quality international enterprise partner of Tsinghua, was awarded the 2013 Overseas Enterprise Cooperation Award and the 2013 UICC Overseas Cooperation Consultant Award (http://news.carnoc.com/list/280/280533.html (accessed on 10 November 2019, in Chinese)). The quality of a partnership is based on trust between university and industry, and this trust is greatly endorsed by a mature institutional environment for IPR protection [49]. In the case of the Center, both parties were satisfied with the allocation of IPR ownerships, but the institutional environment of China's Triple Helix for IPR protection is far from mature.

As a leading science and engineering university in China, the practices and principles adopted by Tsinghua in handling Triple Helix inter-organizational relations are always followed by other Chinese universities [60]. Therefore, Tsinghua's standpoints on and methods for IPR protection are crucial for optimizing the institutional context of China's Triple Helix linkages. The Overseas RDMO of Tsinghua has taken charge of negotiating with international industrial partners regarding issues of IPR ownership. The Tsinghua administration sticks to the following principles: first, the IPs produced by the joint R&D institutes affiliated with Tsinghua are owned by the nation. If ownership of the IPRs of the R&D results produced by Tsinghua researchers is easily taken by international industrial partners, this can be regarded as a loss of national assets, unless both sides can agree on the terms of this ownership; second, the price of IPR ownership must be equal to the real value of the related patents; third, the R&D products created by Tsinghua researchers need to be highly valued and protected by the university (Interview THU UA 01,02).

However, Tsinghua's disadvantage in dealing with IPR with UTC came from inadequate regulations and inexperience. While the Tsinghua side was willing to transfer their half of the IPR ownership to UTC, this deficiency of the university administration resulted in an unsuccessful result, as described by a Tsinghua researcher of the Center:

> In the first five years, each side (Tsinghua and UTC) owned 50 percent of each IP, and both sides had the rights to use these patents produced by the Center. Once, UTC wanted to buy the half (of the IPR) of a patent owned by the Tsinghua side; however, the Overseas RDMO had no idea about the charge. They just randomly set a price of 100,000 US dollars. But UTC deemed it too expensive. The UTC side thought that they had invested one million US dollars every year; the price of 100,000 US dollars was unreasonable. In the end, UTC gave up and both sides did not achieve an agreement. (Interview THU-UTC 06)

This situation was explained by a staff at the Overseas RDMO:

> We are accumulating our experience and learning from foreign institutions. We learned a lot when the headquarters of the UTC research institute invited us to the US. However, our standpoint is different [from those of the university researchers]. We have to balance the benefits of different stakeholders: we need to respect the willingness of the university teachers, consider the benefits to the university, and keep a favorable relationship with the enterprise. We also need to take the issues of law and contract into consideration. (Interview THU UA 2)

The director of the Overseas RDMO was designated by the President of Tsinghua as the legal representative to sign contracts with international industrial partners. Before decision-making, the Overseas RDMO needed to make sure that the international technology transfer would not harm the interests of the nation (Interview THU UA 02).

The service mentality of Tsinghua researchers brought them into a disadvantageous position in terms of IPR ownership negotiations, and such a mentality was common among Tsinghua researchers. They believed that when their international industrial partners paid for joint R&D projects, and the researchers repaid them with expertise, it was reasonable for the industrial partners to own the IPRs. As a result, the university side easily gave up IPR ownerships in negotiations (Interview THU UA 01,02).

This way of giving up IPR ownerships was opposed by the Tsinghua administration. The Overseas RDMO had been considering measures for IPR ownership distribution. The university side believed that, in principle, an enterprise inputs the funding for a joint R&D project or invests in establishing a joint R&D institute, and the R&D outputs are shared by both sides. However, in many cases, the large international enterprises are stern and insist that the IPRs should be entirely owned by them. As a result, it is often difficult for both sides to reach an agreement. Even though the Tsinghua leadership had set up a principle of IPR ownership sharing, it was not strictly enforced. Tsinghua allowed flexibility for the department and university researchers to judge whether giving up IPR ownerships was worthwhile. However, the Overseas RDMO had set some corresponding measures to restrain such cooperation. It charged high administration fees to joint R&D projects that gave up the university's IPR ownerships. For example, if the total project budget was one million yuan, the university charged a 250 thousand yuan administration fee. The percentage was much higher than the fee charged to other joint R&D projects. These fees were used for a university development fund (Interview THU UA 01,02). This countermeasure was explained by a staff member of the Overseas RDMO:

> The university allows you to take on these projects, although such undertaking can only make money. However, these projects, compared with those projects which can share the IPRs, have to pay extra administration fees. The university cannot forbid the researchers from conducting these projects, since the university administration cannot judge for the researchers whether these projects are indeed worthwhile or not. But the university does not encourage researchers to conduct the kind of project which loses IPR ownership. Charging an administration fee is meant to indirectly limit the researchers who undertake this kind of cooperation through disadvantaging the benefits of the projects. When the researchers feel the projects are not worth it, they will redirect themselves to other cooperative projects. The university can also use these administration fees as university development funding to improve the university R&D environment and facilities. We have a series of specific measures [to use the development funding]. (Interview THU UA 02)

The countermeasure implemented by the Tsinghua administration was reasonable. Large international enterprises pay great attention to IPRs; they are clear that it is highly cost-effective to cooperate with Chinese universities, since they can easily own the IPRs with low financial inputs from such R&D cooperation [85,86].

The Change in IPR Ownership Distribution Pattern

As agreed, in the first five years of the Center, every patent was equally owned by both sides. Inventors—in most cases, the Tsinghua researchers of the Center—had the right of authorship to the patents. In the second five years, an unsuccessful case of purchasing IPR ownership partially resulted in UTC's decision to transform the IPR ownership distribution regulation. The more important reason was the shift of the Center's research orientation from knowledge innovation to technology and production innovation. The outputs of the joint research were more likely to be transferred into products (Interview THU-UTC 08).

In the second five years, when Tsinghua and UTC advanced their research topics of interest, the IPRs of the outputs generated from the UTC research topics were entirely owned by the enterprise. This was also applicable to the Tsinghua side. In addition, if UTC was interested in the outputs owned by Tsinghua, Tsinghua needed to sell them to UTC upon agreement on the price. If the patents generated benefits, the inventors could have economic compensation. This transformed distribution regulation was more beneficial to UTC's acquisition of the patents it deemed promising in the market (Interview THU-UTC 07, 08).

As a result, UTC had more authority in the distribution of IPR ownership. In joint R&D cooperation, large international industrial partners are always more powerful in terms of IPR protection. UTC understood that the Tsinghua administration was inexperienced in dealing with IPR issues, and the university researchers did not really care about the IPR ownerships (Interview THU UA 02). Some of them deemed it to be a wise change:

> The pattern of the second five years is better; it is actually troublesome if every patent is jointly owned. It may cause conflict if a patent is going to be transferred to product. Many of us [the Tsinghua researchers] feel that the changed pattern is clearer and more scientific than the one before. It is hard to imagine that when UTC wants to launch a product, it has to get approval from Tsinghua. (Interview THU-UTC 06)

Moreover, the changed pattern made it easier for Tsinghua researchers to publish papers, as elaborated by a Tsinghua researcher of the Center:

> In the past five years, if I wanted to publish a paper, the paper needed to be reviewed and approved by UTC. Nowadays, if I publish a paper regarding the research projects allocated to the Tsinghua side, I do not have to get approval from UTC; this truly provides us with more flexibility. (Interview THU-UTC 07)

In the third stage, when interactions between organizations in the three sectors become increasingly intensive, logics of intellectual property turn out to be a key factor in the Triple Helix development, obviously in the case of the Tsinghua-UTC Center. The problem of IPR in China originates from the inadequate reinforcement of patent law [87]. Nevertheless, the awareness of Chinese government and universities about IPR protection was raised in the process of cooperating with international industrial partners. In the past three decades, a dramatic change has taken place in the percentage of invention patents granted in China. In 1990, 70 percent of invention patents granted in China were owned by international actors; this proportion decreased to 50 percent in 2008. From 2009 to 2012, it declined substantially from 49 to 34 percent. In 2017, it became 22 percent. (See Figure 3). Among various reasons for this trend, the intensive interactions between universities and international industrial partners on the platforms of joint R&D institutes have made a difference.

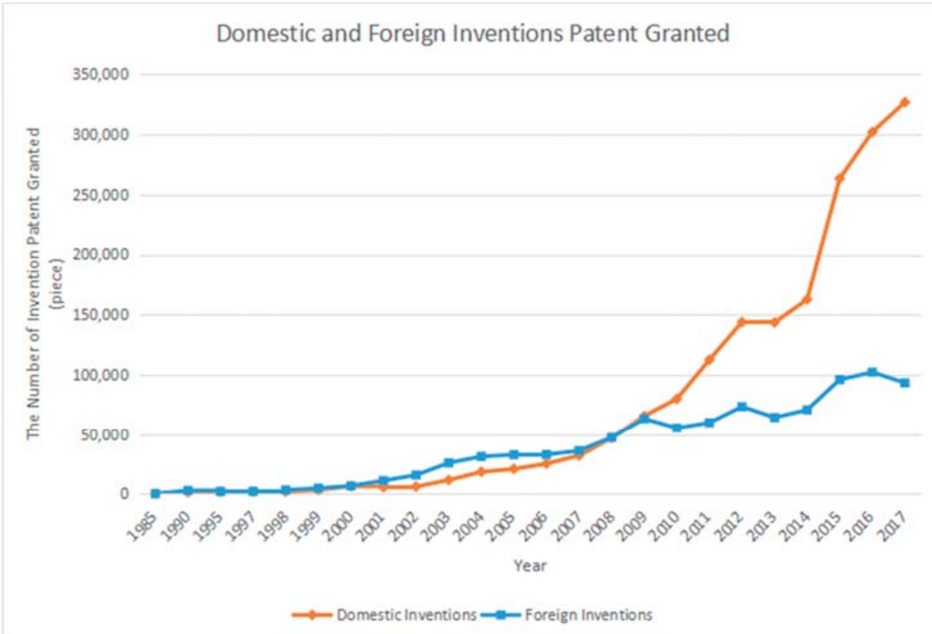

Figure 3. Domestic and foreign invention patents granted (1985–2017). Sources: *China Statistical Yearbook 1999-2018* (For example: http://www.stats.gov.cn/tjsj/ndsj/2018/html/CH2015.jpg (accessed on 1 December 2019)).

As for the logics of civil society, which is a Western concept and seems absent in the discourse of the study, the Chinese government lacks effective policy measures to stimulate bottom-up initiatives. Future studies can explore whether the endeavors of joint R&D institutes have the potential to create functional mechanisms that can coordinate between top-down control and bottom-up initiatives [49].

4.4. Stage 4: Institutionalization of Joint R&D Institute

In the final stage, to facilitate the institutionalization process, logics of the market competition environment and democracy in policymaking are important in collective sense-making and belief shaping [49]. The joint R&D institutes provided benefits for international enterprises, including convenient access to governmental resources and the local market. As a result, these advantages may help accelerate their acceptance by the local market, and then reduce the Chinese enterprises' profit margins. Moreover, joint R&D institutes may also cause a crowding-out effect [16] between international and Chinese enterprises: the deeper the international enterprises' involvement in the university R&D, the less the universities will be in demand to cooperate with Chinese enterprises. This is partly because the university R&D resources are limited. On the other hand, the enterprises would be concerned about issues of confidentiality if two enterprises in the same field set up joint R&D institutes at the same university. For example, Huawei Technologies Co. Ltd., which was considering creating a joint R&D institute with Tsinghua, gave up the plan because of the existence of the Tsinghua-Cisco Lab. Therefore, it has been commonly acknowledged that Chinese enterprises' market competition is insufficient, which has limited their innovation capacity [88]. The joint R&D institutes can raise the logics of market competition in China's Triple Helix linkages.

Regarding the logics of democracy in policymaking, the relevance of this study can be predicted when major challenges of international R&D cooperation have raised importance of policy-makers to improve the institutional environment of the transnational and national innovation system, including week IP protection, insufficient coordination for competition, and low degree of technology transfer.

5. Conclusions

In conclusion, this study discussed the institutional logics generated in the institutionalization process of a joint R&D institute at a Chinese research university; furthermore, it zoomed in on the ways in which the collision between Western and Chinese institutional logics have affected China's transnational Triple Helix relations. The institutionalization process of joint R&D institutes results in an increasing difficulty to differentiate Western from local logics. In the Chinese context, some of the so-called Western logics have taken roots: (1) vision and patience in knowledge innovation and (2) beliefs in technology innovation as a key to economic growth [49]. Some have started to sprout: (1) market orientation and market competition; (2) process management; and (3) IPR protection. The others are still largely absent: (1) civil society, and (2) democracy in policymaking.

The Chinese are pragmatic, and they are inclined to find shortcuts to outcomes [83], but this does not necessarily mean they do not have patience in knowledge innovation or that they will ignore process management. Because of the Chinese mentality of being pragmatic and retaining flexibility in various conditions, Chinese people always preserve space for digesting the Western logics that they deem useful and that have proved favorable for economic development.

The most significant policy implication is related to the improvement of patent law. The case of the joint R&D institute's IPR ownership distribution provided experience and lessons for improvement. China's incomplete IPR legal system is the largest barrier for substantiating the university–industry R&D cooperation. At the institutional level, the universities need to improve the professionalism of their legal advisory offices. When negotiating with the large international enterprises about IPR ownership distribution issues, the professionals representing the university side need to hold explicit principles and standpoints. This can ensure equal R&D partnerships. As a result, the university researchers would be more stimulated and confident in participating in joint R&D institutes as the university's legal section could protect their rights and interests.

Secondly, the policy vacuum in international joint R&D cooperation needs to be filled. This deserves joint efforts from related governmental agencies (i.e., the Ministry of Science and Technology and the Ministry of Education) and research universities. The experience and lessons from the joint R&D institutes would be especially valuable for filling in this policy blank. Moreover, science and technology policies can provide specific incentives to attract international enterprises to locate their innovative-oriented R&D in China. For example, if the government could provide matching funds for international enterprises to locate their technology-intensive and forward-looking R&D activities in Chinese research universities, the joint R&D institutes would achieve both financial and human sustainability.

Thirdly, the joint R&D institutes, with the logics of process management, technology innovation, market orientation, and IPR protection, can serve as experimental bases for completing policy-making related to university technology transfer systems. For example, The law of the People's Republic of China on Facilitating the Transfer of Scientific and Technological Results, revised in 2013, emphasized the connection between R&D outputs of joint R&D projects and university professional promotion systems; moreover, it aimed to improve the distribution principles of IPR ownerships. The policy-makers have realized that the disconnection between joint R&D outputs and university promotion systems has led to the inefficiency of China's innovation system. The joint R&D institutes can provide a stable and enabling environment to measure the institutional mechanisms that can contribute to an innovation-oriented system.

Finally, the logics of vision and patience in knowledge innovation and process management could resolve the university researchers' "role strain" between governmental and industrial research projects. The governmental research projects enjoy higher scores in the university's professional promotion system and they can generate more publications. The university researchers, especially the junior ones, have to allocate more time and energy to governmental projects. In contrast, Su's [89] study in an American context drew a different conclusion from that found in the flagship Chinese research universities: in the United States, affiliation with joint R&D institutes is more appealing for junior researchers than for tenured faculty members; in the United States, working closely with industry can produce more publications, which is advantageous for professional promotion [89].

The pattern of the Center in the first five years, with its forward-looking and interdisciplinary features, had great potential for generating high-quality publications. Whether and how joint R&D institutes can contribute to resolving the university researchers' "role strain" between governmental and industrial projects deserves future research.

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Mobility, Knowledge Transfer, and Innovation: An Empirical Study on Returned Chinese Academics at Two Research Universities

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Abstract: This study provides an in-depth analysis of the effects of academic mobility on higher education innovation through an empirical study on returned Chinese academics at two research universities in China. Based on data obtained through document analysis and semi-structured interviews with 15 academic returnees, this paper aims to examine the everyday interactions between individual returnees and their environment, with a focus on exploring how different institutional contexts affect returnees' capacity for integration and innovation. It finds that returned academics play an important role in promoting higher education innovation in China through mobilizing their transnational capital and resources. However, their capacity to innovate is largely subject to their working environment. Evidence from the study suggests that differing institutional contexts make a substantial difference to the reintegration experiences of returnees and to their contributions to institutional changes. This paper provides a window into the changing institutional environment in China and the academic lives of returnees there. It also provides important implications for talent policy decisions.

Keywords: academic mobility; knowledge transfer; higher education innovation; institutional environment

1. Introduction

In an interconnected and globally competitive environment, cross-border movement of students and academics has become widespread. Mobility is regarded as the *sine qua non* of the global academy [1], as it is often linked to notions of internationalization, global connectivity, transnational academic capital, and the knowledge economy [2,3]. For a long time, the policy discourse on academic mobility has been largely framed by the emotive term "brain drain", which is defined as a one-way flow of emigration of skilled human resources from one country to another [4]. This view, however, has recently given way to studies on the notions of "brain gain" and "brain circulation". Substantive literature has shown that the global movement of highly qualified people can be a powerful booster, enhancing knowledge transfer, international cooperation, and innovation [5,6]. In the name of sustainable development, the mobility of talented people, including scientists, academics, scholars, and entrepreneurs, has become incorporated into the "sustainable development" strategies of institutions, regions, and nation-states [7]. There is a pro-talent mobility agenda among institutional and national policy frameworks that stresses the need for the circulation of knowledge and human resources to achieve sustainable development on a global scale.

One of the countries that has captured attention is China, because it has had a large and persistent outflow of students and scholars since it opened up to the world in the late 1970s [8]. Recently, this flow has begun to reverse itself due to China's strong economy and its government's policy of bringing back talented overseas Chinese. In higher education sectors, China has an explicit goal to attract overseas academics back to its universities, as well as a policy agenda of building world-class universities. Despite the increased number of returning academics in China and elsewhere, research on return academic moves remains scarce. In fact, studies of academic mobility have focused extensively on outbound moves, pull–push factors, and the experience of being abroad [9]. Less attention has been paid to the experiences and discourses entailed in the process of return.

Given the large and growing percentage of overseas academics returning to China, the question of how best to engage returned academics in China's academic system has become an increasingly pressing issue, and an important topic for research. While there is a small amount of academic literature on the subject of Chinese academic returnees, the institutional perspective has often been overlooked. This study provides an in-depth analysis of the effects of academic mobility on higher education innovation and attempts to include an institutional level of analysis. Specifically, it aims to answer the question of how different institutional contexts affect returnees' capacity for integration and innovation. Based on data obtained through document analysis and semi-structured interviews with 15 academic returnees at two different types of Chinese universities (one a traditional research university in the interior of China's Northwest, and the other a newly established university in a more cosmopolitan city on China's South Coast), this study explores the everyday interactions between individual returnees and their environment, with a focus on the opportunities and challenges faced by the faculty members in different institutional contexts. The researchers find that the differing contexts of these two types of universities make a considerable difference to returnees' reintegration experiences and their contributions to institutional changes. This paper provides a window on the changing institutional environment in China and the academic lives of returnees there. It also provides important implications for talent policy decisions.

2. Literature Review: Return Academic Mobility in China

China is an important example of a nation that has sought to attract its overseas nationals to contribute to domestic development. In recent years, the Chinese government has adopted various programs to lure back its overseas talents, including the "One Hundred Talent Program", the "Program of Introducing Discipline-Based Talent to Universities", and the "Overseas High-Level Talents Program". These programs have aimed to encourage the return of overseas scientists, scholars, and entrepreneurs by providing them with particularly favorable conditions and incentives, including competitive salary packages, start-up funding, housing subsidies, spousal employment, children's education, a special policy for residential permits, etc. [10–14]. Some interesting studies [12,15] have explored the strategies used by the Chinese government to entice the best and brightest scholars from overseas. Studies have shown that policy matters in terms of attracting overseas Chinese scholars, especially top-tier academics [16]. However, policies are not necessarily the most significant deciding factors for returning academics. Research on the motivations of Chinese academics has indicated that individual factors, such as one's career prospects, national identity, sense of cultural belonging, and family considerations, are as influential as state interventions [14]. Other macro conditions, such as the rapid growth of China's economy, its improved research system, and its increasingly internationalized higher education system, have been identified as driving forces behind the recent tide of return moves [14,17].

In higher education sectors, Chinese universities have been actively recruiting faculty who have been educated or who have worked overseas as one of their key strategies for promoting internationalization and pursuing world-class status. Returnees are assumed to "hold four basic superiorities—English proficiency, academic vision, technical skills, and ability to develop foreign relations" [16] (p. 230). Empirical studies have confirmed their unique role in knowledge transfer and capacity building, through introducing new ways of teaching, research, and university management [14]. Rosen and Zweig [10] employed the term "transnational capital" to analyze the uniqueness and advantages of returned academics. They defined transnational capital as a kind of scientific and technical human capital that is "based on international knowledge or linkages accumulated overseas that are not readily available in China" (p. 111). In their comparative study of 109 returnees and 90 local academics, Rosen and Zweig claimed that returnees surpassed their domestic colleagues in terms of language proficiency, international publications, and international collaborations. This was also evident in Jonkers and Tijssen's [18] research on 76 returned Chinese life sciences researchers. They found that there was a positive correlation between international experience and scientific productivity. Researchers with a higher international profile tended to be more likely to collaborate internationally and have more publications. Similarly, in their case study on a group of distinguished returned young scientists (Thousand Youth Talents Scheme Scholars), Li, Yang, and Wu [16] showed that the contribution of those returnees to Chinese scientific research and internationalization was particularly substantial.

Despite the advantages that returnees have, studies have shown that integrating into China's academic system is not always an easy and beneficial process [14,19]. The tension between returnees and their local counterparts is a perpetual theme in the literature. Evidence has suggested that the preferential policies created for returnees have stimulated resentment from local scholars who feel that their degrees are devalued and their positions are threatened by the massive influx of returning scholars [11,14,20]. This has further hampered the integration of returnees into local institutions and complicated the talent policies in China. Moreover, some studies have pointed out that returnees encounter challenges posed by the existing university structures and academic culture, which include the bureaucracies of institutional administration, the absence of an invisible college, complicated interpersonal relationships, and the lack of an effective academic culture that supports high-quality teaching and research [14]. Adopting a qualitative research approach with 56 returnees across five universities, Chen [14] illustrated how the institutional environment has a direct impact on the academic lives of returned scholars.

The scarce literature that currently exists on academic returnees in China has examined such themes as the general pull and push factors affecting return mobility, the individual perspectives of the returned academics themselves, and the returnees' contributions to China's higher education internationalization efforts. The institutional perspective on recruiting and retaining returned academics has received little attention in the literature. However, some research on international faculty mobility has pointed out that institutional policies and realities play an important role in the attraction and integration of international faculty [21]. Rumbley and de Wit [22] pointed out that the lives of international faculty were heavily affected by the circumstances they faced within a particular institutional setting. As such, the institutional level of analysis is vital to understanding the "lived reality" of returnees in a specific context and the consequences of mobility. However, such analysis is rarely covered by the academic literature. To fill this gap, this paper includes an institutional level of analysis in its qualitative inquiry into the everyday interactions between the returned scholars and their work environment.

3. Methods and Methodology

3.1. Background and Case Selection

This paper is derived from a qualitative study on the experiences of Chinese academic returnees and the role they play in the educational systems and individual universities where they are employed. The academic returnees in this study were Chinese-born scholars who had completed at least their undergraduate education in China, then obtained their doctorate degrees overseas, and subsequently returned to Chinese universities upon graduation or after several years of work abroad. As a qualitative study, the purpose of this research was to achieve a nuanced understanding of the returned academics' lived experiences and the meaning they made of those experiences.

While the larger study involved 72 returned academics from seven research universities across China, the present paper focuses on 15 academics in two out of the seven universities. They were chosen as focal participants because of their contrasting accounts of working in different institutional environments. The two featured universities, one in the interior of China's Northwest (called West University, a pseudonym) and the other in a more cosmopolitan city on China's South Coast (called South University, also a pseudonym), were selected because both of them are research-intensive universities but differ significantly in terms of geographical location and history, as well as internal governance and management. By drawing on a sub-set of data from the larger study, this paper analyzes in depth the effects of academic mobility on innovation from an institutional perspective.

3.2. Data Collection and Analysis

Semi-structured interviews, non-participatory observation, informal conversations, and document analyses were used to collect data. The fieldwork was conducted in the fall of 2013 and 2018, respectively. Individual in-depth interviews were the primary method of data collection, as this method facilitates a deeper understanding of personal perspectives and experiences [23]. Each interview lasted between 60 and 90 minutes. The interviews were conducted in Mandarin Chinese and were recorded with the participants' permission. Pseudonyms were used to protect the identities of the participants. A total of 15 participants were included in this article, seven from West University and eight from South University (as shown in Table 1). In addition to interview data, we used policy texts, newsletters, reports and archival records as supplementary data for analysis.

Table 1. Characteristics of the qualitative sample.

No.	Pseudonym	Univ.	Gender	Age Group	Discipline	Academic Rank	Years of Stay Abroad
F1	Dr. Chen	West Univ.	M	40–49	Physics	Professor	6–10
F2	Dr. Lin	West Univ.	M	40–49	Biology	Professor	6–10
F3	Dr. Jin	West Univ.	M	40–49	Engineering	Professor	6–10
F4	Dr. Cao	West Univ.	M	40–49	Biology	Professor	6–10
F5	Dr. Ma	West Univ.	M	30–39	Food Science	Professor	1–5
F6	Dr. Yang	West Univ.	M	50–59	Management	Professor	11–15
F7	Dr. Mao	West Univ.	F	30–39	Chemistry	Associate Professor	1–5
F8	Dr. Wu	South Univ.	M	50–59	Mechanical Engineering	Professor	16–20
F9	Dr. Zhao	South Univ.	M	40–49	Materials Science	Professor	11–15
F10	Dr. Huang	South Univ.	M	50–59	Management	Professor	16–20
F11	Dr. Gao	South Univ.	M	50–59	Chemistry	Professor	16–20
F12	Dr. Liu	South Univ.	F	40–49	Environmental Science	Associate Professor	11–15
F13	Dr. Yu	South Univ.	M	40–49	Electronic Engineering	Professor	11–15
F14	Dr. Zheng	South Univ.	M	30–39	Finance	Associate Professor	6–10
F15	Dr. Li	South Univ.	M	40–49	Physics	Professor	6–10

The data analysis in this study was informed by a combination of inductive analysis of the raw data, deductive coding from the literature review, and the objective of the larger study from which this paper emerged. The coding process was aided by both a manual coding strategy and a computer-assisted program called Nvivo 11. In terms of data interpretation, we followed the *Standards for Reporting on Empirical Social Research* in AERA Publications [24] "to review the corpus of available data to locate all relevant instances to support the claims, to search for confirming and disconfirming evidence, and to try out alternative interpretations" (p. 38). We contextualized the analysis in a larger global and social context instead of simply listing the major findings.

4. Findings

4.1. A Limited Engagement: Return to West University

West University, located in the western region of China, is a university that has more than 80 years' history. As one of China's "Double First-Class" universities (a total of 42 top universities were included in the list of "Double First-Class" universities plan, an initiative to develop world-class universities and first-class disciplines in China), the university enjoys a long-term reputation for academic excellence and has contributed greatly to China's development. In recent years, the university has initiated a timetable for achieving world-class status. Recognizing that the overall quality of its faculty team did not match that of the best universities nationally and globally, West University has made great efforts to recruit first-rate scientists and scholars from an international talent pool.

However, due to geographical restrictions in the less developed western region of China, West University is in a disadvantaged position with regards to attracting overseas talents compared to its counterparts in more cosmopolitan cities. According to the university's annual report, less than 20% of its faculty members were educated overseas. To compensate for its geographic disadvantages, it has adopted special talent schemes to attract Chinese graduates from the top Western universities. These relocation packages include not only a housing subsidy, seed funds, and spousal employment, but, more attractively, full or associate professorships for selected candidates. Six out of seven participants from West University were granted the title of full professor, including a newly graduated Ph.D. These scholars took advantage of institutional policies to shorten their transition from junior to senior professor. It was an opportunity few of them expected to have had they returned to other research universities in first-tier cities in China.

4.1.1. Opportunities and Expectations

According to our participants at West University, there were at least three major opportunities, or rather expectations, for them. First, they were expected to publish in international journals. Such publications are now used as one of the major indicators to evaluate a university's performance [14,25]. West University has implemented reward policies to encourage its faculty to publish in international journals. For example, if a paper is published in a leading international journal, the author(s) will receive certain monetary rewards. The cash reward for a paper published in an international top-tier journal could be equivalent to a whole year's salary. The respondents acknowledged that they had advantages in international publications compared to their local colleagues due to their rigorous academic training, English proficiency, and global linkages, a byproduct of their mobility experiences [14]. Through analyzing the curriculum vitae of the participants, we found that they were strong in international publications, and many of these articles had been coauthored with colleagues at their previous institutions abroad. Several empirical studies have demonstrated the positive correlations between mobility and international publications and co-publications [18]. This may be one of the main reasons that West University is keen to attract overseas academics.

Second, the returned academics were expected to foster the international development of the university. In order to compete globally and nationally, West University has made substantial efforts to embrace internationalization as a key institutional priority. The participants, in general, were actively involved in, and had positive experiences with, international service. More than half of them mentioned their roles in, and contributions to, the expansion of the international dimensions of the university. These included developing international programs, promoting cooperative agreements with foreign institutions, boosting faculty visits and student exchange programs, organizing international conferences and meetings, and participating on international committees or serving as editors/reviewers for international publications. No matter whether these activities were formal or informal, the returnees were acting as bridges, connecting the international and domestic academic communities [16].

The third task for the returnees was to develop "English as medium of instruction" (EMI) programs to internationalize the curriculum. The number of EMI programs has become an important indicator of internationalization in Chinese universities. The first-tier universities in China, on average, offer 5–10% of all courses in English [26]. To meet such criteria, West University provided additional funds and resources to encourage its faculty, especially returnees, to establish EMI programs. According to the participants, such initiatives created opportunities for them; they were more competent and competitive in EMI teaching compared to their local colleagues due to their language proficiency, familiarity with original English textbooks, and inter-cultural competencies.

Overall, our respondents from West University were positive about their overseas experience in learning and knowledge transfer, but they were negative about their roles and contributions in driving organizational changes.

4.1.2. Challenges and Constraints

Despite the opportunities and advantages that the returnees had, most of them shared that the journey home was more difficult than anticipated. They typically cited "resistance from local colleagues", an "unsupportive academic culture", and "complicated local power relations" as major barriers to reintegration. All respondents from West University, except one, reported certain degrees of exclusion and marginalization from their local colleagues, as the following two quotations illustrate:

> There is a conflict between the top administrative level [of the university] and the subsectors in terms of talent policies. While the university leadership places great emphasis on recruiting overseas talents, some deans and department chairs are sensitive to these policies, because they see us [returnees] as a threat. Although they may not resist boldly, they place invisible barriers for us and control most of the local resources. To be honest, without the support of our president, I don't think I could survive here. Basically, this is a cultural issue. Half of the faculty graduated from here. They are quite traditional and less likely to embrace new ideas or changes. . . . You need to learn how to deal with the local politics. (Interview with Dr. Yang, a professor in Management)

> Before you joined the university, they were very welcoming, but once you joined them, things changed. You feel that they are trying to push you away. [Interviewer: Why? They have invested time and energy to attract you back.] Certainly, the university wants you to stay, but the colleagues are different. They want you to serve them, even in very small things. (Interview with Dr. Mao, an associate professor in Chemistry)

Both of the above participants reported difficulties adjusting to the local institutional culture. The tension between returnees and local nationals was a recurring theme in our research. As the quotations suggest, some local nationals were upset by the unequal treatment of local and returning scholars and felt that the talent policies favored "outsiders" who might not necessarily be as capable as they were. Furthermore, they worried that their positions and authority might be challenged by those returnees. These mixed feelings of admiration, worry, and resentment from the local nationals created barriers for the returnees and limited their career opportunities [11,14,27].

The situation was worse for lower-ranked junior returnees. Take Dr. Mao, whom we quoted above, as an example. Due to the university policy that only full professors are qualified to lead a laboratory, Dr. Mao, as an associate professor, had to join a senior professor's team rather than be an independent principle investigator (PI). She used the word "miserable" to describe her overall experience at West University. "I thought I could have a career here, but I was wrong. I can barely survive, let alone fulfill my career aspirations," she explained.

Indeed, even those who returned with the title of full professor and were granted autonomy as PIs felt frustrated with the bureaucratic academic culture at West University. As Dr. Cao, a professor in Biology, explained,

> Recently, the university has planned to adopt a PI system to build up innovation teams and encourage cooperation between PIs. In my view, the implementation of this new policy should first ensure equal access to resources for each individual PI. However, the reality here is that the large research teams have substantive power in gathering important resources, while the small teams with one or two students can barely secure funds. How could there be real and fair cooperation? A small research team is doomed to be merged into the large ones. This so-called cooperation is an exercise in acquiring personal resources in the name of collective strength. This problem at bottom is caused by the academic culture here, which is very complicated. (Interview with Dr. Cao, a professor in Biology)

According to Dr. Cao, the lack of an open and fair academic culture was a major barrier to reintegration. He attributed this to the established traditions of inbreeding at West University. To him, inbreeding enhanced the power of senior faculty and particularism ("not fair competition for all" in his language), which made changes difficult. This is consistent with previous studies on academic inbreeding that have concluded that inbreeding has deleterious impacts on universities and tends to engender traditionalism and solidify hierarchical relationships [28]. Although policy makers at West University were aware of the potential consequences of inbreeding and had adopted new policies against it, the entire academic culture was still less open than it could be.

The case of West University demonstrates that it is relatively easy for a university to adopt new policies and schemes to attract overseas academics, but it is far more difficult to change its academic culture to make it not only welcoming but also conducive to these academics' career development [14]. Despite this, our participants at West University were overwhelmingly positive about the future of their university. They believed that the increased number of returned academics would finally produce a critical mass on campus to promote institutional innovation.

4.2. A Critical Mass: Returning to South University

South University, located in the most cosmopolitan city on the South Coast of China, is a newly established university, which has been widely regarded as a pioneer of higher education reform in China. It distinguishes itself from other traditional Chinese universities in terms of its research profile, internationalization, entrepreneurship, and innovation in university governance, education, and faculty hiring. More than 90% of its academics hold overseas doctorates. The English language is commonly used as the medium for teaching and research. Drawing on the best practices of world-class universities and aiming at becoming such a university itself in 20 years' time, South University has adopted a new type of governance and administration system—including the adoption of a Board of Regents (board of trustees), tenure system, and PI structure borrowed from the Anglo-Saxon model. Due to its international outlook and its high similarity with Western universities in terms of governance and operation systems, South University is often considered one of the most attractive destinations for returned Chinese academics among Chinese universities.

4.2.1. Opportunities and Expectations

In addition to the three common expectations (international publications, international development, and teaching in English) that were discussed in the above case, the returnees to South University perceived "higher education reform", "societal impact", and "student cultivation" as three major opportunities, or rather tasks, for them.

At South University, the culture of innovation and the structure supporting the development of new ideas in education entice people who have dreams or a vision for higher education. All the participants shared that they came to the university because of its mission of higher education reform and because the university's governance system matched their aspirations of "being an enactor of the changes" [14]. This was particularly true in the case of Dr. Li, a full professor in Physics. Dr. Li first settled in a traditional university in China before joining South University. He was disappointed by the bureaucratic structures and local politics at his former university, and was attracted to South University due to fewer drawbacks related to the traditional power relations in an academic context. As he explained,

> The system at South University is close to that in the US where faculty and students are respected and have autonomy in decision making. This kind of governance system is more suitable for faculty coming back from overseas. ...The interpersonal relationships are relatively simple and everyone can get along well with each other since they are independent in their research. I once planned to return to the US after one year's stay here, but the comfortable working environment changed my thoughts. (Interview with Dr. Li, a professor in Physics)

Like Dr. Li, there were two other established returnees who joined South University after several years' experience in traditional universities in China. They were, in general, satisfied with their experiences of working at South University, where they enjoyed more academic autonomy and freedom compared to their previous universities. "We are making history," one of the interviewees claimed.

For young and ambitious scientists, the PI system, with its sufficient initial research funding and lab space, was usually considered a major reason for joining South University. Unique to South University, all faculty members, from assistant professors to full professors, were hired as independent PIs, and granted start-up funds starting from 3 million RMB. This is different from West University or other traditional universities in China, where junior faculty are usually not eligible to be independent PIs and have to work in a large team under the supervision of senior researchers [14]. As expressed by the participants, working at South University as a PI turned out to be a rewarding experience. They were allowed the autonomy to develop their research interests with great flexibility, which they might not have been able to achieve had they returned to a traditional university in China.

In addition to the nontraditional structure and innovation culture at South University, the region where the university is based also played an important role in luring top-quality scholars and scientists, who saw in its strong and quickly developed industries a great opportunity for their academic career advancement and the transfer of their research to industry. Most of the interviewees in this study were in the STEM fields. They acknowledged that they were attracted to South University because of its location in the city that has the greatest dynamics in terms of technology and economic development. Considered "the new Silicon Valley", the city is regarded as the global epicenter of high-tech design and manufacturing. "Not many places in the world are like this. For an applied science researcher, this is an attractive land," explained Dr. Zhao, a professor in materials science. Dr. Zhao was a successful young scientist before he returned to China. However, he was tired of the cycle of the closed-loop academic system ("applying for funds—publishing papers—applying for more funds—publishing for more papers," in his words), and expected to do valuable things that had real societal impact. The good industrial foundation of the city and the close connection between the university and industry gave him opportunities to transfer his research and products to industry. Dr. Zhao, an excellent scientist, took advantage of these opportunities through successful entrepreneurship. He had two companies under his name. To him, generating new knowledge and turning it into new products and services was a better contribution to society than solely publishing papers. Returning to South University enabled him to extend his traditional role as a faculty member and researcher to become an entrepreneur.

The returned academics' efforts at promoting "societal impact" were reflected not only in their research practices, but also in their teaching. Dr. Wu, a chair professor in mechanical engineering, had long been committed to the improvement of engineering education to meet the needs of future society. Dr. Wu had been studying and working in Europe, Australia, the United States, and Hong Kong for more than 20 years. He had rich experience in connecting university to industry and training young talents with an innovative mixture of project-based and humanities-enriched team learning.

When asked about his viewpoint on "industry–university–research", he shared that "students are the key." Dr. Wu had been actively involved in exploring new approaches to engineering education. His exploration in education was fully supported by the university. To him, South University was a perfect place to cultivate future start-ups and innovators, given the high quality of its students, the favorable local industrial network, and the open and supportive university culture that promoted innovation and the cultivation of innovative minds.

The term "societal impact" emerged again and again in the interview data. The participants emphasized the importance of creating and transmitting new knowledge throughout society. How to facilitate universities' better interaction with society has become one of the major themes of higher education reform [29]. This has also been conceptualized as a "third mission" of higher education in the literature. According to Laredo [30], the third mission entails not only industry-related research, but also social engagement that exceeds universities' two traditional missions of teaching and research. However, the role of mobile academics in engaging in the third mission of universities has seldom been captured in the literature on the academic mobility of Chinese scholars. Most studies have focused on the effects of mobility on teaching and research, and little attention has been paid to the involvement of mobile scholars in entrepreneurship-related activities. The case of South University demonstrates that returnees are playing a key role in reaching out to society through their knowledge and technology transfer.

4.2.2. Challenges and Constraints

Compared to their counterparts at West University, participants from South University seldom raised the issue of local resistance. This was because the returnees had created a critical mass to reinvigorate the academic culture to be more open and tolerant of diversity. The new governance adopted by South University, on the one hand, gave returnees more freedom and autonomy to transfer their transnational academic capital [10], while, on the other hand, putting them under great pressure in terms of publications and performance.

In contrast to the old "iron rice bowl" employment system (which refers to a permanent job position with a steady monthly income) [27], new faculty at South University are hired under a six-year contract with a competitive annual salary package. The benefit of the tenure system used at South University is that faculty receive an annual salary significantly higher than the average level in China; however, at the same time, they are under great pressure to publish [14]. The stakes are high, and so is the stress level. The sixth-year—with its "up-or-out" decision point—is a critical moment in the careers of South University faculty. All of the young tenure-track faculty in our research admitted to certain degrees of burnout under the pressure for publications and securing grant money. Both the university and the academics hungered for success in bidding for state-funded research projects and publications in top journals. The pressure was always there for this young university and its young researchers.

Moreover, working at a new university where there were no ready laboratories in an established PI system, the new faculty had to spend a large amount of time on building their laboratories and platforms, especially in the beginning. Dr. Yu, a professor in electronic engineering, regarded himself more as a start-up founder rather than an academic. He explained,

> You have to start from scratch. Everything is under construction, including the buildings and academic disciplines. It takes a lot of time to design the lab and get devices and the team in place. Then, you have to race against time to get research and work done in a few months that might otherwise have taken a few years, even at an established university. (Interview with Dr. Yu, a professor in electronic engineering)

Dr. Yu further illustrated how a large research platform was needed for greater or more complicated research, and this meant more time required to build the platform up. Facing the challenge of the lack of ready platforms, several interviewees shared that they had been using their transnational connections to maintain continuity in their research. According to an official report published by South

University, international collaboration is one of the key characteristics of the university. This can be attributed to the returnees' transnational networks and their ability to mobilize international resources.

Finally, the participants also reported that they felt overwhelmed by a large amount of managerial work. The governance structure of South University is quite decentralized, with academic departments as the main units. All departments are newly founded, so the founding academics have had to spend a large amount of time on recruiting faculty and staff, and setting up the department structure, regulations, and protocols. When there were few faculty in the early stage of the departments, the ones who first joined the university played multiple roles in research, teaching, and management. The urge for quick development increased the workload and pressure on these faculty. Dr. Zheng, an associate professor in Finance, used the term "sandwiched academic life" to describe his situation of trying simultaneously to teach, research, advise students, serve on committees, and deal with managerial errands. "There are so many managerial affairs and meetings in the day time. I'm either sitting in a meeting or on the way to a meeting. There simply are not enough hours in the day to do research," he complained.

Dr. Zheng was not alone. All academics at South University were under great pressure to balance managerial work and research. The pressure was further enhanced by the managerial practice at South University of "mak[ing] academic performance accountable" [27](p. 507). Under the discourse of competition, quality assurance, and accountability [31], the faculty were urged to be productive and competitive. The quick rise of South University in various university league tables in a short time has been due to the dedication of its faculty.

5. Discussion

The above comparative analysis demonstrates that there were similarities, as well as differences, in the ways that returnees reintegrated into our study institutions (a comparison of the two cases is given in Table 2).

All the participants, from both South and West Universities, were positive about their mobility experiences and believed that overseas experiences brought many social and professional benefits, namely, research strength, capacity to publish in international journals, and resources in international academic networks. The returnee academics were regarded as important nodes in the global networks through which joint research is carried out and knowledge is transferred [13,32]. This reflects the general conclusion from the literature that mobility and innovation are often associated—bringing diversity, global connectivity, new perspectives, and innovation [11,14,16,33]. It can be argued that academic mobility can go a long way to improve the quality and outcomes of teaching, learning, research, and public service, which ultimately promote sustainable development in higher education.

However, mobility is not always positive and beneficial for scholars. There are constraints that limit the effectiveness with which mobility operates. This study suggested that, irrespective of individual characteristics (disciplinary background, length of stay, and academic rank), the returnees' contributions to innovation were largely subject to institutional and cultural conditions. In general, those who returned to West University were less satisfied with their work conditions and less positive about their roles in making innovation than those who came back to South University. As we discussed above, most of the respondents from West University found the institution's heavy bureaucratic and hierarchical governance structures burdensome and experienced certain degrees of resistance. Like most traditional universities in China, West University has a long history of inbreeding, which is often associated with a whole range of worrisome issues—hierarchy, respect for age, complicated personal relationships, and traditional ways [28]. These constraints constituted a limit to the effective engagement of the returnees. The case of West University demonstrates that there was a gap between the university's leadership team and sub-organizations in terms of talent policies. The university leaders had the vision of bringing in talents, but, in practice, many ambitious returnees were excluded at the departmental level.

Table 2. A comparison of the data from two case institutions.

<table>
<tr><th></th><th>West University</th><th>South University</th></tr>
<tr><td>Institutional characteristics</td><td>• Research-intensive university
• More than 80 years' history
• A large number of its faculty were educated domestically (many graduated from the university itself)
• Located in a less-developed region</td><td>• Research-intensive university
• Newly established
• More than 90% of its academics hold overseas doctorates
• Adopted a new governance structure that is similar to American universities
• Located in a cosmopolitan city</td></tr>
<tr><td>Policies for attracting overseas talents</td><td>• Housing subsidy
• Seed funds
• Spousal employment
• Associate or full professorship</td><td>• Housing subsidy
• Seed funds
• Independent principle investigator system</td></tr>
<tr><td>Returnees' perceptions of opportunities/advantages</td><td>• Publication in international journals
• Serving the international development of the institution
• Developing programs/courses by using English as the medium of instruction</td><td>• Opportunities to build something new (i.e., new department, programs, research platforms)
• Transfer of research into industry
• Promotion of societal impact through teaching</td></tr>
<tr><td>Returnees' perceptions of challenges</td><td>• Resistance from local colleagues
• Heavy administrative process
• Hierarchical structures due to inbreeding</td><td>• Pressure in publication and performance
• Starting from scratch to build research labs and platforms
• Overwhelmed by a large amount of managerial work</td></tr>
<tr><td>Perceptions of contributions</td><td>• Negative about contributions</td><td>• Positive about contributions</td></tr>
</table>

In contrast, those who came back to South University seemed to face few problems in reintegrating into the system. All participants from South University reported high levels of job satisfaction and were positive about their role in knowledge transfer, disciplinary development, and institutional innovation. This could be attributed to the easy integration of returnees into the local culture, a high level of academic autonomy, sufficient funding support, and a governance structure similar to their prior overseas institutions. Despite the friendly and favorable internal environment, the returnees also expressed that they were under great pressure to publish and make their academic work accountable. Under the influence of neoliberal changes in higher education in China, South University has adopted a new type of managerial governance, with features such as the "up-or-out" tenure model and a PI system with quantifiable evaluation. These practices, on the one hand, have improved the quality and efficiency of the institution, while, on the other hand, creating unprecedented pressures on its faculty. It can be argued that the "lived reality" of academics at South University manifests the changing role of faculty in China; that is, it has become more competitive and performance-based.

The case of South University serves as an example of mass mobility and how returnees collectively can establish a new model of world-class university in China. As more overseas scholars return to China, it is inevitable that China's academic culture will become more open and competitive on a global scale [14]. However, it is important to note that this research does not aim to propagandize the idea that returned academics are necessarily "better" than their domestically-trained counterparts, or that South University is "better" than West University. No data from the study prove this premise. Instead, the research aims to capture the trend of changes in different types of universities in China and how they affect returnees' capacity to innovate.

6. Concluding Remarks

This study has contributed to the current debate on academic mobility and higher education innovation by taking into account China's particular context. Evidence suggests that returnees play an important role in promoting higher education innovation in China through mobilizing their transnational capital and resources. However, their capacity to innovate is largely affected by their working environment. The findings from our two case study institutions indicate that the lives of returnees were colored heavily by the circumstances they faced in their specific context. It can be argued that differing institutional contexts make a substantial difference to the reintegration experiences of returnees, especially their capacity to adjust and innovate. Therefore, in analyzing the consequences of return mobility, it is vital to consider institutional contexts, especially the relations between returnees and their host institutions. This paper points a way forward with respect to understanding academic mobility by considering the institutional level of analysis.

The findings of this study also shed light on the implementation of national and institutional policies to recruit overseas talents. We argue that mobility should continue to be encouraged by special policies and funding. Simply implementing policies, however, is not enough. More attention ought to be paid to improving institutions' working conditions and institutional culture in order to harvest the benefits of mobility.

In line with an educational sustainability position, this study has implications for higher education institutions seeking to optimize the role that mobile academics play in their competitiveness and internationalization in the increasingly inter-connected global knowledge economy. If academic mobility can be better understood by local institutions as a triple-win strategy for both the sending and receiving institutions, the mobile and local academics, and the global community of related disciplines, this will plant the seed for the institutions' future sustainable and comprehensive development.

Despite the significance of this study, it has several limitations. It does not include the perspective of university administrators on the hiring of academic returnees, their promotion, or other aspects of their work. Further research is needed to include the voices of administrators and domestically-educated faculty in order to assess the consequences of mobility on higher education more accurately. It would also be interesting to explore differences between disciplines and, in particular, how return mobility plays out among social sciences and humanities faculty versus those in STEM fields.

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Does Money Accelerate Faculty Mobility? Survey Findings from 11 Research Universities in China

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Abstract: In the context of global innovation systems, it has become a universal law that the resource elements of scientific and technological innovation, such as talents, flow along the track of high efficiency to the regions that can produce high benefits. As faculty in research universities are important resources of scientific and technological innovation, developing countries such as China have sought to accelerate the transnational mobility of faculty by leveraging income. This study endeavors to gain a better understanding of the motivations for and the outcomes of faculty mobility at Chinese research universities and to determine whether attaining higher income levels through academic mobility can be considered a lever for facilitating change and improving the status of the academic profession in China. Using survey data from 445 faculty members at 11 major research universities in China, this study found a significant relationship between mobility frequency and indirect income. The findings also revealed, however that employees' different attitudes toward income during the process of mobility are a key variable in confirming academic professional boundaries. The findings suggest that more successful mechanisms to attract or retain talented scholars should be developed and that these mechanisms should not focus exclusively on income.

Keywords: global innovation systems; Chinese research university; faculty income; academic mobility; academic labor market; ordinary labor market

1. Introduction

In today's globalized world, with the closer economic and technological links between countries, the original barriers have been continuously broken, and the mobility of innovative resources such as talents, technology, and capital has continued to increase. Faculty members have the option to transfer between universities and across working sectors. They may consider moving from one institution to another or to a working environment outside the education sector for a variety of reasons, including intellectual collaborations with other scholars [1], better working conditions [2,3], better facilities [4], more scientific output [5], and family reasons [6,7]. Job mobility for faculty can produce a number of positive outcomes, including an increase in productivity [8], new knowledge, and reported satisfaction [9–11].

However, a limited number of studies have focused on the influence of money on faculty mobility. Will faculty members choose to move because of high income (Is money the key factor that influences faculty mobility?)? Does income in China increase following a move compared to countries with mature academic labor markets, such as the U.S. and European countries? We know little about experiences with and motivations for mobility among faculty from countries in which the academic profession is undergoing dramatic alterations in terms of emerging or changing academic labor markets.

Mindful of the facets of the "pull-push" phenomenon [12], this study endeavors to gain a better understanding of the motivations for and the outcomes of faculty mobility at Chinese research universities and to determine whether attaining higher income levels through academic mobility can be considered a lever for facilitating change and improving the status of the academic profession in China. Using responses received from the Survey of Faculty Mobility, which was carried out by the Changing Academic Profession project team from mainland China (http://www.hse.ru/en/org/hse/cinst/academic_profession_eng), this study examines factors that influence faculty mobility at 11 major Chinese universities. This study seeks to resolve three main questions: 1) Does job mobility result in changes to income? 2) What factors, such as academic output, working environment and professional satisfaction, contribute to mobility? 3) Is the relation between faculty mobility and income correlated with gender, academic titles, qualification, experience abroad, or discipline?

Related to the main research questions, this study also endeavors to determine the types of academic institutions and faculties that benefit most from mobility. In China, the frequency of faculty mobility is currently somewhat low; however, the development of globalized education may encourage greater interest in moving to another academic institution and/or to employment outside academe. More comprehensive investigation of the role of faculty mobility is of great significance for improving the environment of the academic profession, promoting job satisfaction and facilitating the management of faculty in higher education institutions (HEIs).

2. Literature Review

Faculty mobility has become a barometer for the development of HEIs, and a lack of job mobility due to constricted labor markets, which could affect income, may not reflect the actual competence of faculty members [13]. Today, the academic profession is price-negotiable, and income affects mobility to a large extent among academic institutions and between the academic profession and other fields.

2.1. Income: An Important but Not Essential Factor

In certain countries, the income levels of academic faculty make it difficult for them to maintain a middle-class lifestyle, which renders the academic profession a marginal occupation. While recent studies of the academic profession have found that the impact of income on faculty mobility is important and is accompanied by conditions that may offset the detrimental effects, a number of factors can influence faculty mobility, including income, research resources, institutional prestige, academic cooperation between faculty members, university geographic location, and citizenship. While income and opportunity for promotion play crucial roles, other factors are also important. In a review of the 44 reasons for faculty mobility at the University of Michigan, Moore (1998) found that income ranked fifth, below research grants, research opportunities, departmental reputation, and institutional or departmental leadership.

Income is an important indication of one's satisfaction with the working environment and has considerable influence on mobility [14–16], seeking to negotiate better pay and/or research facilities in another institution. Schools where teachers rated their working conditions as more satisfactory had lower attrition rates and also were schools with higher rates of low-income and/or minority students [17]. Further, lower salaries for academic positions may encourage faculty to transition away from the academic profession. As observed in the responses to the U.S. Survey of Doctorate Recipients, salaries are approximately 20% lower in the education sector than in the business and industry sectors in the U.S. [18]. Additionally, foreign-born, non-native citizens who are highly productive in research and have held appointments for a short period of time are more likely to leave academe and transition to industry [12]. Faculty members who have close contact with industry are more likely to leave the academic profession. In some cases, the move to industry occurs full-time, while it may be part-time in other cases. In the biotechnology field for example, faculty members prefer to job-hop among biotechnology companies. Fearful of a large exodus, Harvard eliminated its restriction on the commercialization of biotechnology research to avoid losing its best biology scholars to biotechnology companies.

A recent study [19] found that faculty who chose not to move reported satisfaction with the time available for research and expressed stronger organizational commitment. Those who were dissatisfied with the fairness of work evaluations and who believed tenure decisions were not merit-based were more likely to leave. Some researchers explain that the basic difference between the academic and ordinary labor markets lies in employees' different attitudes toward income [20]. In the academic labor market, faculty members pay greater attention to academic accumulation, new discoveries, innovation, and academic dissemination. Therefore, in the process of moving, scholars focus on academic elements such as academic production, institutional prestige and academic title.

2.2. Direct and Indirect Income

Prior research [21] identified four types of indicators of direct faculty income before and after job mobility: annual salary from one's HEI; other income from one's HEI; income from other academic institutions; and income from other employers. In addition, there are three indicators of indirect income [22]: research funds (which can be divided into vertical research and lateral research, with the former mainly from government agencies and the latter from industry); housing (because job negotiations often include this item); and spouse's income (because academic mobility is, to a great extent, not a personal but a family decision, or it is at least greatly affected by family).

2.3. Correlations Between Faculty Mobility and Faculty Prestige and Performance

Scholars are keen to assess the impact of institutional prestige and academic performance on faculty mobility. Although there are certainly differences in the conclusions found in the literature, the mainstream view asserts that institutional prestige is more influential for position access and mobility than academic performance. For example, Caplow's [23] study of the mobility of liberal arts faculty found that during the mobility process, institutional prestige was more important than one's previous academic performance. Similarly, in the research of "Global inequality in the academic system", Gerhards [24] concluded that universities' symbolic capital seems to be more important than the quality of a department.

2.4. Correlation Between Faculty Mobility and Gender

In general, previous studies have found that female faculty members are less likely to move than their male peers [25,26] because of family caretaking considerations or a preference for larger metropolitan areas [27]. Additionally, some female faculty members may prefer to be affiliated with an institution with higher prestige [28] and may opt to accept a part-time position at a higher prestige institution rather than a full-time appointment at a lower prestige institution. Kacey Beddoes and Alice L. Pawley [29] held that a married woman may be constrained by family responsibility and her husband's career, and the final decision regarding a move is often based on benefit to the husband [30]. In addition to, Jöns' study [31] "transitional academic mobility and gender" with the visiting researchers in Germany found that the academic world of female researchers had less interest in mobility than that of their male colleagues. The limitation of female mobility in their work life found in the literature related to both education and research is family-concerning responsibility especially taking care of their children [32]. Similarly, in the Italian labor market, Alkadry and Tower [33] address an overlooked manifestation of pay discrimination against women in the labor market, and men's salaries increase faster than women's, which is more significant for employee mobility between companies and represents a form of gender salary punishment. Gender bias related to income and mobility is generally similar in the U.S. and Europe.

2.5. Study of the Impact Factors for Faculty Mobility in Different Countries

The literature on the impact factors for faculty mobility has significant national characteristics [34]. The existing literature has noted many concerns about faculty mobility in the U.S. Meanwhile, scholars from other parts of the world have also had many discussions about the impact factors for faculty mobility. Compared with the U.S., European scholars have focused more on the macro and meso levels in recent years, especially the study of how faculty mobility is influenced by various policy designs [35] in which money is the key factor that facilitates scholars' mobility. Some European scholars even believe that the European academic labor market is far from being fully developed and that appropriate policy intervention is thus necessary. Some European countries fully consider the influence of money when designing policies to facilitate mobility (e.g., Sweden), and some non-European countries tend to welcome and promote faculty mobility and incorporate the basic concept of leveraging money to promote faculty mobility in their policy design (e.g., Brazil, Chile, and South Africa).

There has been a general lack of research on job mobility among Chinese faculty members [19], particularly empirical research, and the findings of previous studies have not been consistent with respect to the relationship between income and mobility. In 2008, a questionnaire survey of 268 faculty members at six Chinese universities found that material aspects such as income and preferential treatment were the key factors for promoting faculty mobility [36]. By contrast, in 2012, an analysis of sample data for full-time faculty members at Chinese public four-year universities found that job satisfaction was the most significant variable in explaining faculty mobility intention [37].

3. Data and Method

Description of the Data

Ethical approval for this study was not sought due to the absence of an Ethics Committee process. The following steps were undertaken to ensure due consideration of the ethical process: All participants were provided with written information about the nature and purpose of the research project. Faculties were informed about the study at the beginning that data collected may be included in publications, and that they could withdraw their contributions at any time without penalty. All institutional information was de-identified; all faculty responses were anonymous; faculties were given the choice to respond to the survey questionnaire. Their submission of the questionnaire was taken as indication of their informed consent to participate in the research.

The Survey of Faculty Mobility was distributed to 1,100 faculty members from 11 Chinese research universities. All the included universities are part of the "Double first-class construction" project ("Double first-class construction" project: In 2017, the Chinese government introduced the project to establish world-class universities and world-class disciplines; to date, 42 universities have been in the list of world-class construction universities, 99 universities have been in the list of world-class disciplines construction universities). There were three primary considerations when selecting this sample. The first was the geographic distribution and characteristics of the included universities: four in east China (Peking University, Tsinghua University, Fudan University, and Shanghai Jiao Tong University), three in central China (Wuhan University, Huazhong University of Science and Technology and Central South University), and four in west China (Lanzhou University, University of Electronic Science and Technology of China, Northwestern Polytechnical University, and Northwest Agriculture and Forest University). The second consideration was the universities' rankings: the selected 11 universities are ranked in the top 50 Chinese Universities [38]. The third consideration was the academic disciplines of the universities. Of the 11 universities, five are comprehensive universities, five are polytechnic universities, and one is an agricultural university, which corresponds to the general proportion of comprehensive universities (33%), polytechnic universities (36%), and agricultural universities (5%) among Chinese research universities. Overall, the 11 selected universities represent 28% of the total number (39) of Chinese research universities; thus, the sample can represent the general characteristics of faculty mobility at the main research universities in China (but it cannot represent the characteristics of some research universities associated with a specific industry, such as the Ocean University of China).

Survey research on faculty mobility generally focuses on a single discipline [39,40] or several disciplines [41,42], and the sample sizes of these studies are often small—between 100 and 400 subjects—because many potentially mobile faculty members are busy elite scholars [40,43]. The disciplines offered by Chinese universities are traditionally divided into five categories, including science, engineering, agronomy, medicine, and liberal arts [44]. Not all research universities have fully established these five disciplines, however. Therefore, in accordance with typical practice in Chinese academic circles [45–47], the sampling method in the present study involved conducting questionnaire surveys of faculty members from all five disciplines at the universities that have fully established those disciplines. In the universities with three or four of the five disciplines, the questionnaire survey was administered only to faculty in the corresponding established disciplines. For example, the University of Electronic Science and Technology of China does not offer medicine and agronomy disciplines, so the sample for that university included only three categories.

The survey consisted of two phases. The goal was to obtain 250 completed questionnaires from faculty members with job mobility experience and to obtain completed questionnaires from a certain proportion of faculty members without job mobility experience, which could serve as a reference sample. The time span for phase 1 was October 2011 to December 2011, during which the questionnaire surveys were administered to and completed by faculty members at Peking University, Tsinghua University, Fudan University, Shanghai Jiaotong University, Huazhong University of Science and Technology, Wuhan University, and the University of Electronic Science and Technology of China. One responsible person in the department of personnel in each university was selected as a contact person to distribute the questionnaires. The proportion of faculty members with job mobility experience in the sample was intentionally increased during the survey phase based on the low response rate [48]. A total of 100 questionnaires were administered at each university, and the proportion of faculty members with job mobility experience was 70–80%, while the proportion of those without mobility experience was 20–30%. A total of 700 questionnaires were disseminated during phase 1, and 302 valid questionnaires were collected, including 166 from faculty members with the mobility experience. Because the goal (250 questionnaires from faculty with mobility experience) was not reached during phase 1, a second phase was conducted at four universities from October 2012 to February 2013. Of the 1100 total questionnaires distributed, valid responses were received from 445 faculty members, for a response rate of 40.5%. The sample frame and distribution of respondent characteristics are presented in Table 1. Of the 445 respondents, 59.6% had mobility experience, and of those with mobility experience, most had only one experience (56.9%), most were men (76.3%) and most were full professors (51.3%).

Table 1. Sample frame of faculty mobility survey at Chinese research universities.

Total sample		=445	Title	Professor	40.2% 51.3%
				Associate professor	36.3% 37.1%
Gender	Male	73.3% 76.3%		Assistant professor	1.1% 0.4%
	Female	26.7% 22.8%		Lecturer	19.1% 10.3%
Mobility experience	Yes	59.6%		Teaching assistant	1.4% 0
	No	40.4%		Other	1.8% 0.9%

In this study, faculty mobility is generally divided into three categories. The first is long-term mobility, which refers the occurrence of a substantive employment relationship, such as changing academic jobs. The second is periodic short-term mobility [49]. The third category is conventional periodic short-term mobility, such as flying faculty [50]. The first type of mobility is very different from the other two, and although many scholars contend that long-term mobility can generate knowledge transfer, it is generally a zero-sum game. However, some scholars assert that the key benefit of long-term mobility is constructing research networks [51]. The influence of mobility is reflected not only in the zero-sum game between brain drain and brain gain but also in the way that brain circulation is managed and promoted [52]. Therefore, this paper focuses on long-term mobility. The survey defined mobility as four main types of substantive moves in the past ten years: 1) a move from an overseas academic institution (university, research institution or enterprise) to a Chinese HEI; 2) a move from another Chinese HEI to the respondent's current HEI; 3) a move from another research institution (mainly the Chinese Academy of Sciences and the Chinese Academy of Social Sciences) to the respondent's current research institution; and 4) a move from a non-research institution (mainly government and finance-supported institutions) to the respondent's current institution.

The items were designed based on the literature on academic mobility and included 27 questions that addressed the respondents' experiences with mobility, changes in income, and satisfaction with income. The questionnaire used in this study covered three types of factors that may affect faculty mobility: twelve personal and family factors (total personal income, potential income and insurance benefits, housing size, personal professional development opportunities, academic titles, workload and work pressure, spouse's workplace, spouse's total income, spouse's career development opportunities, distance from relatives and friends, educational opportunities and environment for offspring, and elder care); nine academic institutional factors (prestige of colleges and departments, cooperation and relationship with colleagues, total research funds, research equipment and library facilities, extent of connection with academic circle, educational ideas and culture, atmosphere of academic freedom, quality of student source, and academic systems and policies); and six social factors (university geographic location, climate of university geographic location, whether the university is located in a metropolis or not, social atmosphere in the location of the university, recreational and leisure facilities in the community, and educational facilities in the community).

4. Results

4.1. Income Change Following a Move

When comparing faculty members with a previous record of mobility with those who were never mobile, direct income was relatively similar; however, the indirect income of those who were immobile was much lower than that of the mobile faculty members. The results reveal that marked income changes occur for faculty members following a move, but unlike mobility in the industry sector, academic mobility leads to a decrease in faculty members' direct income. The findings presented in Table 2 indicate that for faculty members with mobility experience, a significant change in income occurred after their most recent move, with indirect income increasing and direct income decreasing.

Direct income. According to the survey responses, the total amount of the four direct income sources declined from ¥170,000 (approximately 26,282 US dollars) to ¥133,000 ($20,563). Overall, after a move, the salary received from the respondent's HEI decreased by an average of ¥36,000 ($5566), followed by decreases in income from other employers (down by ¥9000 or $1391) and other academic institutions (down by ¥1000 or $155). Only one item rose sharply: other income earned from the HEI (increased by ¥9000 or $1391). The decrease in salary is due to the scholars' return to China from the U.S. or from European countries where their incomes were higher. On average, the incomes of Chinese scholars who returned from the U.S. decreased by ¥161,923 ($25,033).

Table 2. Percent change in income indicators resulting from the mobility of faculty members at Chinese research universities.

	Direct Income				**Indirect Income**					
	Salary from HEI (10,000RMB)	**Other Income From HEI**	**Income from Other Academic Institutions**	**Income from Other Employers**	**Total Research Funds**	**Total Lateral Research Funds**	**Spouse's Total Income**	**Housing Size (Sq M)**	**Family's Total Income**	**Family's Total Expenses**
BM *	13.1	1.5	0.6	1.8	18.3	11.1	8.5	113	24.1	11.5
AM	9.5	2.4	0.5	0.9	27.4	12.4	14.6	114.6	19.8	10.5
NM	11.1	3.7	0.3	5	2.9	1.1	4.5	101.3	13.7	4.7
AM-BM	−3.6	0.9	−0.1	−0.9	9.1	1.3	6.1	1.6	−4.3	−1
AM-NM	−1.6	−1.3	0.2	−4.1	24.5	11.3	10.1	13.3	6.1	5.8
BM-NM	2	−2.2	0.3	−3.2	15.4	10	4	11.7	10.4	6.8

* BM = Before move; AM = After move; NM = No move.

Indirect income. Regarding the most recent move of faculty members with mobility experience, the amount of research funds received exhibited a dramatic 50% increase, from an annual average salary of ¥183,000 ($28,293) to ¥274,000 ($42,362). Vertical research funds primarily contributed to this increase. Vertical funds increased by 108%, while lateral funds increased by only 12%. In addition, the respondents reported a 72% increase in their spouses' total income, from an annual average of ¥85,000 ($13,141) to ¥146,000 ($22,572), and housing size also increased (although the increase was only approximately 1.6 square meters).

4.2. Relativity Analysis of Income and Faculty Mobility

As noted in Table 2, changes related to mobility were observed for both direct and indirect income. Does this mean that a relationship exists between income and faculty mobility? Further analysis suggested that direct income was positively associated ($r = 0.198$, $p = 0.023$) with the moving or not variable, and indirect income via total research funds had a significant positive correlation ($r = 0.223$, $p = 0.004$) with moving or not. Neither university geographic location ($r = 0.098$, $p = 0.407$) nor spouse's total income ($r = 0.198$, $p = 0.023$) was significantly associated with mobility. While spouse's total income was positively correlated with moving for female respondents ($r = 0.086$, $p = 0.269$), a similar correlation for male faculty ($r = 0.287$, $p = 0.015$) with mobility experience was not significant. This finding indicates that gender plays a special role in the relationship between income and mobility. The most likely reason is that a male's income is typically higher than his spouse's income. Spouses continue to maintain their salary levels following a move, a result that is consistent with some research on gender, family and faculty mobility [25,53].

Additional analyses revealed that mobility was positively correlated with indirect income. Additionally, mobility frequency was positively correlated with two of the indirect income indicators ($r = 0.372$, $p < 0.001$)—total research funds ($r = 0.536$, $p = 0.002$) and spouse's total income ($r = 0.278$, $p = 0.002$)—but was not significantly correlated with the university's geographic location ($p = 0.220$). These findings indicate that the mobility of faculty members at Chinese research universities significantly increases their indirect income, which may explain why some of these faculty members continue to pursue academic mobility regardless of decreases in their direct income.

Subsequent analyses employed two demographic indicators, gender and age, as control variables to perform partial correlation analysis. As noted in Table 3, gender did not make a difference in the relativity level between income (direct and indirect) and both moving or not and mobility frequency. However, when age was introduced, the correlation level between income (direct and indirect income) and moving or not disappeared. A significant positive correlation was observed only between current direct income and mobility frequency. Additionally, the correlation between mobility frequency and spouse's total income became non-significant when age was considered. This may indicate that when excluding the influence of age, a linear relationship between mobility frequency and direct income can be observed. However, when age is considered, the linear relationship between mobility and income disappears, and there is no relationship between mobility frequency and indirect income.

Table 3. Partial correlation matrix.

		Direct Income	Total Research Funds	Housing Size	Spouse's Total Income
Moving or not	No control	0.328 ***	0.344 ***	−0.075	0.153 *
	Control gender	0.176 *	0.176 *	0.027	0.080
	Control gender, age	0.010	0.065	0.006	0.081
Mobility frequency	No control	0.372 ***	0.388 ***	0.149	0.259 ***
	Control gender	0.363 ***	0.352 ***	0.138	0.265 ***
	Control gender, age	0.195 *	0.268 ***	0.112	0.124

Levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

4.3. Importance and Priority Ranking of Faculty Mobility

As revealed in Table 4, the overall responses to the 27 items (1 = very important; 2 = important; ≥3 = not important) offer insight into the issues that influence decisions related to mobility. Both faculty groups ranked atmosphere of academic freedom, academic systems and policies, and quality of student source as important. Faculty members with mobility experience reported that university location and spouse's career development opportunities had a greater impact on their academic mobility than faculty members without mobility experience. It is worth noting that the faculty members, regardless of their experience with mobility, indicated that direct income and indirect income had little effect on their academic mobility.

Table 4. Mean score and rank of mobility impact factors.

Move Occurred	Importance (Mean)	Rank	Did Not Move	Importance (Mean)	Rank
Personal growth opportunity	1.61	1	Personal growth opportunity	1.603	1
Atmosphere of academic freedom	1.873	2	Educational opportunity and environment for offspring	1.739	2
Extent of connection with academic circle	1.874	3	Spouse's workplace	1.788	3
Educational opportunity and environment for offspring	1.894	4	Extent of connection with academic circle	1.797	4
Academic systems and policies	1.901	5	Cooperation or relationship with colleagues	1.8	5
Prestige of colleges and departments	1.917	6	Research equipment and library facilities	1.8	6
Educational ideas and culture	1.941	7	Academic systems and policies	1.818	7
Quality of student source	1.949	8	Atmosphere of academic freedom	1.833	8
Total research funds	1.958	9	Total research funds	1.844	9
Cooperation or relationship with colleagues	1.992	10	Educational facilities	1.855	10

Rank 1 = Very important; 2 = important; ≥3 = Not important.

4.4. The Importance of Factors Before and After a Move

Table 5 presents the level of importance for select factors before and after a move (1 = Became very wealthy after move; 5 = Became very poor after move). Personal professional development opportunities remained the most highly ranked item following a move. This result appears to illustrate that activities beneficial to one's intellectual and career development take high priority, regardless of the need for relocation. Some of the other items did not change in terms of priority order following a move, including atmosphere of academic freedom, cooperation and relationship with colleagues, social atmosphere, and workload and work pressure. The consistency in the ranking of these items appears to indicate that mobility decisions are made in a manner that ensures similar environments and expectations for work. However, some items were reported to be of greater importance following a move, such as total research funds, research equipment and library facilities, educational facilities in the community, recreational and leisure facilities in the community, and academic titles. The result is not surprising, and there is no doubt that the key factors for attracting talented scholars are academic titles, research funds, and research facilities.

Table 5. Ranking of impact for items related to mobility vs. amplitude of variation after mobility.

Impact Factors for Mobility (Change)	A1 Rank of Impact Factors for Mobility by Faculty Self-Evaluation	A2 Rank of Impact Factor after Move	Change
Personal professional development opportunities	1	1	0
Atmosphere of academic freedom	2	6	−4
Extent of connection with academic circle	3	2	1
Educational opportunities and environment for offspring	4	7	−3
Academic systems and policies	5	7	−8
Prestige of colleges and departments	6	3	3
Educational ideas and culture	7	9	−2
Quality of student source	8	4	4
Total research funds	9	5	4
Cooperation and relationship with colleagues	10	14	−4
Social atmosphere	11	15	−4
Spouse's workplace	12	17	−5
Research equipment and library facilities	13	8	5
Academic titles	14	11	3
University geographic location	15	10	5
Elder care	16	21	−5
Housing area	17	23	−6
Personal total income	18	24	−6
Potential income and Insurance benefits	19	22	−3
Educational facilities	20	12	8
Career development opportunities of spouse	21	20	1
Workload and working pressure	22	27	−5
Climate of university geographic location	23	18	5
Metropolis or not	24	16	8
Spouse's total income	25	25	0
Distance from relatives and friends	26	25	0
Recreational and leisure facilities	27	19	8

4.5. Principal Component Analysis

A principal component analysis (PCA) of the 20 impact factors was performed to group similar items into subgroups for data reduction, the results are shown in Table 6. It can be seen that the measured value of the sample data KMO (Kaiser-Meyer-Olkin Measure of Sampling Adequacy) was 0.802, The Barlett sphericity test was 1936.29 ($p < 0.01$), indicating the suitability for PCA. The PCA resulted in five factors with Eigen-values greater than 1.0 and explained 62% of the total variation. The Cronbach's alpha reliability scores for the five components ranged from 0.725 to 0.809.

The five components were as follows:

Component 1 (departmental influence): four items—atmosphere of academic freedom, educational ideas and culture, academic systems and policies, and quality of student source.

Component 2 (research environment): five items—total research funds, prestige of colleges and departments, research equipment and library facilities, cooperation and relationship with colleagues, and extent of connection with academic circle.

Component 3 (geographic location and social atmosphere): five items—university geographic location, climate of university geographic location, social atmosphere, recreational and leisure facilities in the community, and educational facilities in the community.

Component 4 (income): three items—total personal income, potential income and insurance benefits, and housing size.

Component 5 (spouse): three items—spouse's career development opportunities, spouse's workplace, and spouse's total income.

Table 6. Principal component analysis.

	Component Loadings	Internal Consistency (Alpha)
Departmental Influence		0.809
Atmosphere of academic freedom	0.794	
Educational ideas and culture	0.794	
Academic systems and policies	0.710	
Quality of student source	0.626	
Research Environment		0.775
Total research funds	0.769	
Prestige of colleges and departments	0.703	
Research equipment and library facilities	0.700	
Cooperation and relationship with colleagues	0.559	
Extent of connection with academic circle	0.543	
Geographic location and social atmosphere		0.796
Climate of university location	0.805	
University location	0.781	
Social atmosphere	0.696	
Recreational and leisure facilities	0.681	
Educational facilities	0.465	
Income		0.788
Total personal income	0.870	
Potential income and insurance benefits	0.841	
Housing size	0.714	
Spouse		0.725
Spouse's career development opportunities	0.881	
Spouse's workplace	0.836	
Spouse's total income	0.712	

4.6. Analysis of Faculty Mobility Impact Factors: Relationships between Income and Performance, Prestige and Academic Title

Because of its strong correlation with income, we chose *mobility frequency* as the dependent variable for the regression model. Since housing size was not correlated with moving or not or with mobility frequency, it was not included in the model. The independent variables in the model included the income variables as well as academic titles and prestige of colleges and departments.

As noted in Table 7, a stepwise analysis was employed to assess the additive effects of the variables. The final model has good explanatory power (R-square = 0.698), indicating that the selected variables explain faculty mobility. Overall, the factors related to performance, income, institutional prestige and academic titles contribute to predicting faculty mobility.

Specifically, considering all publications at home and abroad in the past five years as an indicator of academic performance can demonstrate scholars' academic capability. In the regression model, the relationship between publication quantity and mobility frequency passed the significance level test. The income indicators also had strong explanatory power in this model, especially the direct income indicator, with a value reaching 13.2%, while the total research funds indicator for indirect income was over 10%. Another indirect income indicator, spouse's total income, had weak explanatory power, only 2.4%. This result reveals that in the faculty mobility process at Chinese research universities, income continues to play a very important role, which is reflected not only in scholars' personal income but also in their research funds. It is also partially related to the possession of research resources. As an indicator of the prestige of colleges and departments, types of doctoral degrees granted by the institution contributed significantly to this model. When we ranked the prestige of institutions from high to low (based on a scale of 1–4), we found that the lower an institution's rank was, the less often one moved.

Table 7. Regression models of the impact factors at Chinese research universities.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Income	Level of income after move	0.045 ***	0.028 **	0.027 **	0.022 *	0.017	−0.156	−0.169
	Income from projects after move		0.015 ***	0.016 ***	0.011 ***	0.016 ***	0.002	0.011
	Total income of spouse after move			0.006	0.004	0.005	−0.021	−0.071
Academic Titles	Academic titles				−0.345 ***	−0.300 ***	−0.141	−1.714
Prestige	Cumulative overseas academic working time					0.025	0.345	0.124
	Type of doctoral degrees granted by the institution						−0.503	−2.675
Performance	Total number of published papers							−0.013
Adjusted R2		0.132	0.246	0.270	0.374	0.412	0.349	0.698

Levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

This study included cumulative academic work time abroad in the regression model. The results indicate that there was a significant positive correlation between the experience of working abroad at academic institutions (regarded as "international reputation") and mobility frequency. The more cumulative time that was spent working abroad in academic institutions, the more times the faculty member moved. Additionally, academic titles also had an important influence on the regression model. With titles ranked from high to low (1 for professor, 5 for teaching assistant), we found that the higher one's title was, the more frequently he or she moved.

The regression models presented in Table 7 indicate that the effects of income on faculty mobility are weaker than the effects of academic performance. It should be noted that types of doctoral degrees granted by the institution not only contributed to the model but also reduced the explanatory power. This model intuitively demonstrates that among faculty members at Chinese research universities, neither direct nor indirect income is the core impact factor, although they play crucial roles in the mobility process.

5. Discussion

The findings of this study demonstrate that although income contributes to faculty mobility at major Chinese research universities, a number of additional factors remain important for faculty and their work, particularly for those who move to a different institution. The desire for academic performance and institutional prestige are equal to if not more important than income. In fact, Chinese scholars frequently have discussions about the impact factors for faculty mobility at the theoretical level, but most of the impact factors have not yet been tested, and non-monetary factors are considered key for influencing faculty mobility. The first of these is educational background and "guanxi". The Chinese academic labor market is not yet completely marketized [19,54,55], so positive "guanxi" is needed for some aspects, such as obtaining new job information [56], acquiring help in the mobility process [36] and career development following a move [6,57–59], and these close and even private academic contacts are based primarily on the relationship between supervisors and students as well as self-established relationship networks in academic circles. Another of our studies analyzed the curriculum vitae of faculty members from "211 Project" universities and found that the rate of academic inbreeding at a few research universities (even well-known universities at the top of the Shanghai JiaoTong University Ranking list) is still higher than 60%, so the low mobility rate of Chinese academics is related to academic inbreeding. In contrast, the collapse of or tension in "guanxi" at faculty members' original academic institutions is also important for faculty mobility. For example, an interview about faculty mobility among Chinese scholars suggested that academic organizational culture is a significant factor. Academic organizational culture will undoubtedly generate centrifugal forces if the team disagrees, if there are strains in interpersonal relationships and if team members defame each other [56]. The second factor is academic titles. Some studies [60,61] have asserted that the pursuit of senior academic titles provides motivation to transition to a new academic position, but this notion is controversial and has not undergone comprehensive empirical testing. For instance, some studies have found that only a few faculty members transfer to lower-ranked universities because of the pressure of academic titles, while fewer studies have reported that the issue of academic titles is resolved by transferring to lower-ranked universities [62].

6. Implications

At present, affected by the international financial crisis, the economies of developed countries have experienced varying degrees of recession. Thus innovative resources are actively seeking development space abroad, and emerging countries such as China have become the main target. The flow of innovation elements is reshaping the global innovation system. China has paid more attention to the issue of faculty mobility, placing great emphasis on faculty income. The findings herein demonstrate that income is one factor for mobility, but it is not the core factor. The strategic plans developed by university officials or governing agencies can partially but not fully achieve their objectives by simply raising income to promote mobility. Additionally, while the income of Chinese academics that return to their native land to work has greatly improved the total income for faculty members remains lower in China than in the U.S. and in European countries. Based on the research, this paper suggests that developing countries should improve the quality of higher education, the reputation of academic institutions, and the working conditions of faculty members and should guarantee academic freedom. Although income is indeed important, these aspects may be more influential than merely raising income. The findings regarding the relationship between income and mobility should be applied to policy practice areas, for example, effective mentoring of junior faculty members, and ample health and retirement benefits should be provided. Such policies may encourage faculty to consider how and when mobility may benefit them.

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Sustainability of the Belt and Road Initiative: An Integrated, Conceptual Framework for Instructional Communication in China's Universities

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Abstract: China is fast becoming a coveted destination and a hub for higher education among international students, particularly since the announcement of its Belt and Road Initiative (BRI) in September 2013. Consequently, China's higher-education institutions are seeking ways to make international students' educational experience more consistent with their expectations. Nonetheless, instructional communication—that is, communication for the purpose of engaging students academically while reducing problematic misunderstandings in the classroom—is a bane of the educational experience of international students in China. Therefore, this article extends instructional communication and intercultural sensitivity models to pedagogical, learner-centered contexts in an attempt to develop an integrated conceptual framework on sustaining international student–Chinese faculty interactions in the classroom. That framework has three key constructs: (a) the faculty's classroom behaviors and international students' characteristics, (b) international students' instructional beliefs, and (c) learning outcomes. They will serve as the basis for positioning instructional practices in responding more appropriately to enhancing the experience of international students as global learners and toward deepening and sustaining the internationalization of China's higher-education institutions, specifically within the context of BRI.

Keywords: Belt and Road Initiative; developmental model of intercultural sensitivity; general model of instructional communication; instructional beliefs model; intercultural communication competence model

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Alongside its rapid economic development and increasing political impact in the world, China is making significant progress in building up soft power capacities by using education as the key instrument to boost its influence abroad. Marleku [1].

In a nod to the Belt and Road Initiative, the MoE [Ministry of Education] has actively participated in projects launched under its framework, allowing education to play its fundamental, empowering role.—Ministry of Education [2].

At the 19th CPC [Communist Party of China] National Congress, the Party noted that strengthening education is fundamental to the pursuit of national rejuvenation and promised to give priority to education, further reform in education, speed up its modernization, and expand education with which people are satisfied.—Ministry of Education [3].

1. Introduction

A nation's higher-education institutions are a repository of skills, talents, innovation and expertise that drive its economy and its social well-being. China's Belt and Road Initiative (BRI), a massive global-development project launched in September 2013, with the expectation that it has enormous potential to offer greater opportunities not limited to those of one country or of one region or of the business community, is also attracting international students to its universities, projecting the country as an increasingly coveted destination for them, and, as Wen and Hu [4] stated, an emerging regional hub for higher education. Today, more than 60 percent of its more than 492,000 international students are from BRI countries [5]. Those developments have been in the works since 1978, when China opened its doors to the international community, primarily for business partnerships. Since then, its political influence has also grown and its educational system transformed, making it an increasingly popular choice destination for international students. In light of the growing interest of international students in China's higher-education institutions and the reaffirmation of China's commitment to expanding educational opportunities for "Silk Road" countries through scholarship programs [1,6–9], it is imperative, that China sustain the modernization of its educational system and explore strategies for strengthening its instructional capacity [10]. It is against that backdrop that this article develops, within the BRI context, an integrated, conceptual framework for enhancing (classroom) instructional communication between international students and their Chinese faculty. Such a focus departs from the common research emphasis on the teacher's communication skills in the classroom and on her or his competence as the sender of the message [11,12]. But, more important, the present study examines international students' classroom experiences, a palpably missing dimension in instructional communication research in which "college students constitute the group of greatest interest to instructional communication scholars" [13] (pp. 461–462).

Cast against the preceding background, then, the purpose of this article is two-fold. First, it examines classroom misunderstandings strictly as an artifact of interculturality or intercultural constraints [14] and develops a framework that can be used to better respond to international students' classroom concerns, thereby sustaining and enhancing the impact of BRI, specifically through higher education, as the second of the three epigraphs enunciates. The framework presented here is based on the results of previous studies; however, admittedly, it is yet to be confirmed empirically. It focuses and places the onus of understanding on the students' communicative competence—that is, listening to and making meanings of their instructional faculty's oral proficiency in the language of instruction, say, Mandarin Chinese. This article subscribes to the views of De Jager and Evans [11] that even though misunderstandings can occur from a teacher's utterances being insufficiently clear, the learner is conventionally obligated to listen and to pay attention to the speaker. Therefore, this article is not concerned about speech acts used by Chinese teachers to accomplish their communicative goals; rather, it focuses on "misunderstanding [as] ... exclusively related to the hearer" [15] (p. 768). Similarly, as Nelson, Carson, Batal, and El Bakary [16] noted, misunderstandings occur when a hearer perceives the message differently from that intended by the speaker. Thus, any pragmatic failure in understanding—that is, misunderstanding—is attributed to the hearer [16].

Second, it presents an erumpent approach to sustaining BRI by enhancing instructional communication, an approach that departs from the dominant theoretical anchors in the General Theory of Instructional Communication [17–19]. It focuses on the students' lived experiences in a culturally disparate environment, even as it iterates the mission of BRI as a strategic, integrated undertaking geared toward both maritime and educational development of institutional charges—international students.

There are at least three reasons for our focus on higher-education institutions. First, to enhance the instructional capacity of China's universities and colleges. China's Ministry of Education statistics for 2018 indicate that there were 492,185 international students from 196 countries or areas studying in 1004 higher-education institutions in China's 31 provinces, autonomous regions, and provincial-level municipalities [20]. Nearly 60 percent came from Asia, 17 percent from Africa, 15 percent from Europe, and about 8 percent from the United States. International students' communicative competence in a host country's dominant language or in its communication styles is a sine qua non for their effective cross-cultural adaptation to and their success in their new milieu [21,22]. Absent of such competence, misunderstandings and communication mismatches tend to occur for a variety of reasons: the inaccurate expressions used by a sojourner in conversations with a native speaker, the mammoth difficulties and conflicts a student has in recognizing words and in ascribing meanings to and in interpreting them in a classroom, the pragmatic failure that results from a mismatch or discrepancy between a speaker's expressions and a hearer's unintentional misinterpretation, and an undeveloped communicative competence in a language in which nonnative speakers of the language of communication misunderstand a speech act or struggle with expressing themselves [11,12,14,15,23,24]. "Misunderstanding," writes Weigand [15], "is a form of understanding which is partially or totally deviant from what the speaker intended to communicate" (p. 769). Such misunderstandings can lead to negative judgments or stereotyping [25], particularly on the part of the instructor.

Second, to provide an erumpent platform that reduces international students' instructional misunderstandings that may result from their inadequate oral proficiency in the language of instruction (or learning) and lead to their failure to accomplish their educational goals, goals consistent with the spirit of BRI. Their pent-up frustration with the teacher–student interaction could result in their negative perceptions of the overall educational experience, threatening a major segment of BRI. Granted, misunderstandings occur in all encounters, including those among native speakers of the same language [14]. For international students in China's universities, however, the mismatch between their professors' speech acts and the students' interpretation of those acts is exacerbated by the students' limited oral proficiency in the dominant language of instruction.

Third, to present a synergy between BRI and China's higher education—an intersection not lost on China's Ministry of Education. As Lavakare [26] put it, China can "ensure economic development through higher education" (p. 13). Particularly noteworthy are that "the skills and talents cultivated by private universities can be adjusted to match emerging industries, and management can be changed according to policy trends" [27] (p. 401). Thus "China's private [and public] universities can help usher in new opportunities for social and economic development (p. 401), trajectories to which BRI is tethered.

The rest of this article is organized into five sections—that is, 2 to 6. In Section 2, we note that our conceptual framework acknowledges the multicultural orientations of international students whose healthful experiences will contribute to sustaining BRI. In Sections 3 and 4, we present a two-pronged theoretical perspective that underpins our conceptual framework. In Section 5, we specify the three key constructs in our framework and conclude in Section 6 with an answer to the question, What's next for the innovative intersection of China's higher education and BRI? We answer that question by presenting five implications of our framework for sustaining BRI.

2. Instructional Communication: Cultural Underpinnings and Classroom Challenges

Because this article emphasizes the cultural characteristics of international students as major antecedent variables in instructional communication in China's university classrooms, it adopts a modified framework that combines key elements of two instructional communication models and two intercultural sensitivity models. The point here is that the conceptual framework will emphasize the multicultural orientations of international students as they communicate in an instructional setting, enabling and sustaining a major initiative that may have contributed in the first place to their presence in China. Higher education, more so in its international realm, is a hallmark of the growing significance of BRI; in other words, as assessment of its impact on the well-being of its participants requires a concomitant assessment of the experiences of international students from BRI countries.

As noted in an introductory paragraph in Section 1, China's universities and colleges are increasingly of interest to international students. Complementing that interest is the phenomenal sustained growth in the country's global influence—politically, militarily and economically—resulting in its commensurate attraction to international students seeking higher education. That influx, partly a consequence of higher education as a state-directed effort under the Belt and Road Initiative, enhances China's political and economic agendas globally, strengthens mutual understanding among Asian countries, and promotes the significance of the Chinese language in global economic and educational markets [28].

In 1950, China received its first group of 33 international students, all of whom came from a handful of East European countries. In 2010, it launched its "Study in China Program" to make it even more competitive in the international student market [28]. This interest in internationalizing China's higher education is noted by Bentao [29], who wrote, "The international mobility of university students is the most dynamic aspect of internationalization and a basic approach of Chinese research universities as they build world-class universities" (p. 88).

Such an increasing interest in international education is underscored by this article's epigraphs, which suggest that education in the international realm reaps healthful tangible benefits for the People's Republic. And international students continue heading to China for higher education. However, as Yu and Downing [30] noted, "Despite these developments, this particular group of students remains one of the most under studied international student populations" (p. 458).

Even though some studies [31–34] have addressed the importance of international students' acculturation in and adaptation to China and to its universities, instructional communication—that is, communication for the purpose of engaging students academically and reducing problematic understanding significantly—is a bane of the educational experience of international students in China. As Wang and Lin [35] noted, "a good knowledge of Chinese learning culture and mutual communication are significant factors for both teachers and students" (p. 195). Moreover, Peng and Wu [36] also suggested that host communication competence and host social communication are two significant pathways to international students' cross-cultural adaptation.

As Chiang [37] noted, "Given that intercultural communicators do not possess the same stock of linguistic and cultural knowledge, problematic understanding is bound to occur" (p. 463). For example, Western students usually do not like their Chinese professors' public reporting of student grades, their professors' in-class criticisms of students who fail to answer questions correctly and their professors' tendency to compare publicly student grades or learning outcomes [33]. Most of the studies on international students enrolled in higher-education institutions analyzed English-medium instruction [38–44] rather than focusing specifically on instructional communication in cross-cultural settings in China's universities. He and Chiang [39] highlighted three key issues: (a) English-medium programs in China's higher-education institutions tend to have teachers and international students who are nonnative-English speakers, (b) international students tend to perceive their Chinese teachers' instructional communication a challenge because of their unusual accent and their sometimes minuscule English-language proficiency, and (c) Chinese teachers' instructional communication style is more culture-bound. Again, these studies are only limited to instruction in English-medium programs, while the present study applies an approach that integrates intercultural sensitivity models to provide a framework of instructional communication in an attempt to enhance international students' academic experience and to reduce their misunderstandings. Therefore, the present study will *also* help international students enrolled in Chinese-medium programs that are mostly offered through the China Scholarship Council.

Thus, it is critical to address instructional communication within the context of cultural differences. The conceptual framework presented here offers pointers toward addressing the challenges of instructional communication, thereby enhancing it between the growing number of international students in China and their Chinese faculty. Even though misunderstandings in instructional communication can reside in the teacher or professor as the message sender who uses inaccurate expression or inadequate speech acts that may result in misunderstandings [11], this article focuses *not* on the professor as the sender of classroom information but on the international student as the receiver of that information. Strictly within the instructional communication context in the Chinese educational environment, this article attempts to fill that gap in the scholarly literature.

We shall now turn our attention to a two-pronged theoretical framework that is the foundation of our integrated, conceptual insights into how the international student experience in China's universities can be enhanced. The theories are deemed appropriate primarily because of their heuristic attributes—that is, their capacity to provide conceptual resources for organizing and explaining our knowledge about the international student in China's multicultural classroom, to serve as guideposts in providing proper contexts for international students' instructional challenges in the classroom, and to focus future research on the pivotal relevance of their experience to sustaining China's landmark development agenda that is revamping the world order.

3. Theoretical Framework I: Instructional Communication Models

Two instructional communication models—the General Model of Instructional Communication [12,18] and the Instructional Beliefs Model [45]—and two intercultural sensitivity models—Chen and Starosta's intercultural communication competence model [46,47] and Bennett's [48] Developmental Model of Intercultural Sensitivity—provide the theoretical basis for formulating an integrated, conceptual framework for enhancing instructional communication, particularly in China's higher-education context.

3.1. The General Model of Instructional Communication

McCroskey, Valencic, and Richmond's [18] model examines instructional communication from a rhetorical, not a relational, approach [19] that assumes that teachers are the primary source of pedagogy in an instructional setting. That model identifies the relationships among four variables or instructional communication components that are most attributable to teachers: teacher traits (e.g., temperament); teacher verbal and nonverbal communication behaviors as perceived by students (e.g., assertiveness, responsiveness, and nonverbal immediacy); student perceptions (e.g., source credibility and task attraction); and instructional outcomes of the learning environment (e.g., cognitive learning, affective learning, and teacher evaluation). In essence, the model emphasizes the general relationships among traits, teacher behaviors, student perceptions, and outcomes, thereby providing a useful framework for investigating instructional communication variables.

Granted, it is the mix of those four components that determines instructional outcomes; however, the framework presented in this article focuses on one component: outcomes, as an indicant of enhanced instructional communication. That variable, based on Katt et al. [17] will be operationalized in two ways: as cognitive learning, that is, how much the international students reported learning from their Chinese professors compared with how much they could have learned if language were not a barrier to their learning outcomes; and as affective learning, that is, how much the international students reported a positive affect toward course material as presented by their Chinese professors. Underlying both dimensions is the students' comprehension of (or competence in) the dominant language of instruction in China's universities.

3.2. The Instructional Beliefs Model

Weber, Martin and Myers [45] formulated an Instructional Beliefs Model that comprises teacher behaviors; student characteristics (that is, orientations and predispositions); and course-specific structural issues as first-order variables. Instructional beliefs, for example, students' judgments about their Chinese language, are second-order variables that influence directly learning outcomes (as a third-order construct).

The relevance of components of both those instructional communication models underpins the conceptual framework presented in this article.

4. Theoretical Framework II: Intercultural Sensitivity Models

A number of sensitivity models have been developed to predict and explain the experiences of sojourners in a new cultural environment and their orientations toward cultural differences. From an intercultural communication perspective, the conceptual framework proposed in this article also draws upon two intercultural communication models, Chen and Starosta's [46,47] intercultural communication competence model and Bennett's [48,49] Developmental Model of Intercultural Sensitivity, both of which are arguably the most investigated in the intercultural communication field. Both fill a gap in the need to better manage the challenges and limitations of—and to enhance—instructional communication between a growing number of Wuhan-area international students and their Chinese instructional faculty. And they also have national implications for China's growing efforts to better structure learning and teaching in its higher-education institutions.

4.1. Chen and Starosta's Intercultural Communication Competence Model

Chen and Starosta [47] developed, in the U.S. context, the intercultural communication competence (ICC) model, which integrates features of both the cross-cultural attitude and the behavioral skills models and which has been tested in a variety of cultural settings. According to the authors, ICC comprised three dimensions: (a) intercultural awareness (cognitive), which refers to the person's ability to understand similarities and differences of others' cultures; (b) intercultural sensitivity (affective), which refers to the emotional desire of a person to acknowledge, appreciate, accept and embrace cultural differences; and (c) intercultural adroitness (behavioral), which refers to an individual's ability to reach communication goals while interacting with people from other cultures. On the basis of this overarching conceptual direction, Chen and Starosta [50] expounded on the nature and components of intercultural sensitivity and developed a measuring instrument, the intercultural sensitivity scale (ISS), by which they distinguished between intercultural sensitivity and intercultural communication competence, pointing out that the ICC includes cognitive, affective, and behavioral ability of interacting individuals in the process of intercultural communication while IS is an independent concept consisting of six variables: self-esteem, self-monitoring, open-mindedness, empathy, interaction involvement, and nonjudgment.

Self-esteem is an individual's sense of self-worth and self-respect. Individuals with high levels of self-esteem are better able to cope with psychological and emotional difficulties in the process of intercultural communication in a host society. They believe that they can manage their interactions in a host culture and will be accepted by others. In other words, individuals with self-esteem have positive attitudes and respect toward intercultural differences, which can lead to effective interpersonal relationships with host members.

Self-monitoring, a construct of intercultural sensitivity, is the ability to identify situational constraints in order to adjust and change one's behaviors to result in competence in communication. Individuals with high self-monitoring can monitor their social behaviors and self-representation in a better way in a diverse cultural atmosphere, and are more observant, sensitive, other-oriented and adaptable in intercultural communication [51,52].

Chen and Starosta [46] defined open-mindedness as "the willingness of individuals to openly and appropriately explain themselves and to accept other's explanations" (p. 8). They further explained that open-minded individuals are more eager to "recognize, accept, and appreciate different views and ideas" (p. 9), and, thus, have a more diverse and broadened worldview and are more actively involved in the process of intercultural communication.

Empathy, also labeled intuition or telepathic sensitivity, is a vital element of intercultural sensitivity [47,48,53]. It refers to an individual's ability to enter into a "culturally different counterparts' mind to develop the same thoughts and emotions in interaction" [50] (p. 5). It enables individuals to be more sensitive to other people's internal thoughts and emotions, more open to others' reactions and understanding in an intercultural communication situation [54,55]. In other words, empathy is a strong indicator of one's level of intercultural sensitivity.

Interaction involvement represents "a person's sensitivity ability in interaction" [46] (p.10). It consists of three important concepts associated with the ability to be interculturally sensitive: responsiveness, perceptiveness, and attentiveness [56,57]. An interculturally sensitive person has the ability to sustain an effective flow of communication by engaging in a culturally proper way during intercultural interactions and by receiving and giving culturally appropriate messages in such settings.

Nonjudgment reflects the quality of a sensitive person by "allowing oneself to sincerely listen to one's culturally different counterparts, instead of jumping to conclusion without sufficient information" [50] (p. 5). Being nonjudgmental can engender interaction and establish relationships with people from diverse cultural backgrounds, and, as an element of intercultural sensitivity, pave the way to a fulfilling intercultural communication experience. This analysis points to the overarching relevance—and the complexity—of the cultural landscape on which the international student navigates. That proess is further enabled—and fostered—by an intercultural development process to which we now turn.

4.2. Bennett's Developmental Model of Intercultural Sensitivity

The Developmental Model of Intercultural Sensitivity (DMIS) is a six-stage process of intercultural learning. It is a journey from resistance to openness and from ethnocentrism to ethnorelativism. It assumes a linear development—that is, having a beginning, an intermediate point, an end. However, it is important to note that, regarding sojourners, the model also considers the possibility of "retreat" or "regress" in the process of cross-cultural adaptation.

The first three stages of the model—denial, defense, minimization—are conceptualized as ethnocentric, by which one's own culture is experienced as a center of reality. In the denial stage, one's own culture is experienced as the only real one, which could be because of isolation or wholly deliberate separation from other cultures. In the defense stage, one's own culture is experienced as the only good one, thus categorizing experiences into "us and them" and generating a concept of "we"-superior and "they"-inferior in cultural perspectives. The last stage of ethnocentrism is minimization in which elements of one's own cultural worldviews are experienced as universal and differences are accepted only at face value.

In ethnorelative stages—acceptance, adaptation, integration—a resident's own culture is experienced within the context of other cultures. These stages represent a journey of the individual from an unknown cultural difference to a known or from the unfamiliar to the cultural difference.

In the acceptance stage, one's own culture is experienced as one of complex worldviews. People at this stage are curious to know about the cultural differences and have respect for other cultures, yet cultural differences do not mean "agreement" and may be judged negatively. At the adaptation stage, one's own worldview is expanded to include constructs from other worldviews and people are able to look at the world with "different eyes", thus changing their behavior to accommodate effectively new and different cultures. This shift of mindset is not an artificial one, but one based on cognitive, affective and behavioral skills of adjustments to a new cultural environment.

The last stage of the Bennett model is integration, in which one's experiences of oneself have become so multicultural that she or he can move into and out of other cultures freely and comfortably. Individuals often confront matters associated with their own "cultural marginality", which Bennett further classified into two: encapsulated and constructive cultural marginality. Encapsulated refers to one's separation from culture and experiences alienation, while constructive acknowledges cultural differences and becomes a necessary part of one's identity and thus a person becomes bicultural, transcending cultural boundaries while maintaining her or his cultural identity.

Ethnorelative orientations are a way to acknowledge cultural differences, either by accepting their significance by adapting to or incorporating cultural differences into one's own personality. Thus, development of intercultural sensitivity is a shift from a narrow, self-centered worldview to an open, mature one that emerges by engaging oneself in meaningful relationships with members of diverse cultures.

5. An Instructional Communication Framework for China's University Classrooms

This article focuses on misunderstandings in intercultural settings in which international students' difficulties with the dominant language of instruction could lead to negative learning outcomes. As both instructional models indicate, several variables determine the students' learning outcomes; however, because of the focus of this article is on students' perceptions of the oral proficiency of their professors vis-à-vis the students' language limitations, the conceptual framework for enhancing instructional communication in the classroom is a linear relationship among three variables: Chinese professor's oral proficiency as perceived by the international students whose instructional beliefs (e.g., the students' instructional ability in Chinese-language) influence learning outcomes (Figure 1). In classrooms, the relationship becomes all too apparent. Why? Because such settings can engender limited understandings that emanate from, among other factors, what Thomas [58] labelled "cross-cultural pragmatic failure" to describe exclusively misunderstandings that arise from the hearer's "inability to understand 'what is meant by what is said'" (p. 91). And she uses "pragmatic competence" to describe the hearer's "ability to use language effectively in order to achieve a specific purpose and to understand language in context" (p. 92).

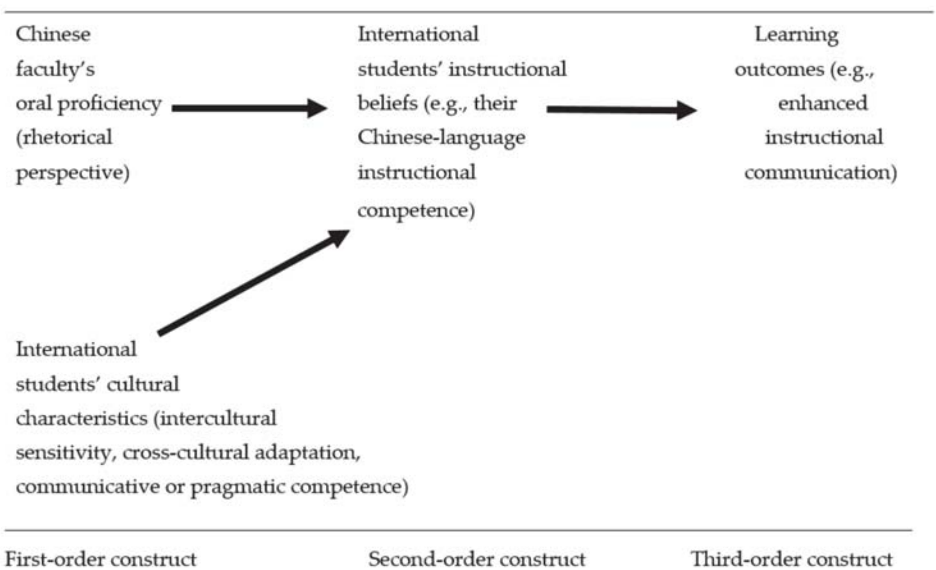

Figure 1. Conceptual Framework for Enhancing Instructional Communication (in China's Universities).

Two approaches to the study of instructional communication dominate the research literature: the relational and the rhetorical [17,24]. In the relational approach, teachers and students exchange information and share understandings mutually. In the rhetorical approach, which is consistent with China's high-context, implicit-communication style, instructional communication is a teacher-controlled process that views the teacher as the primary source of information (in additional to selected readings) and students as receivers and learners.

The framework presented in this article has two first-order variables: oral proficiency and student characteristics, both of which influence students' instructional beliefs about their professors' communication proficiency. Student characteristics include the five elements outlined in Byram's [59] model of intercultural communicative competence:

- attitudes (savoir être), that is, one's openness and readiness to suspend disbelief about other cultures and belief about one's own;

- knowledge (savoirs), that is, one's interactions with individuals and with society;
- skills of interpreting and relating (savoir comprendre), that is, one's ability to interpret an event from another culture and relate it to one's own;
- skills of discovery or interaction (savoir apprendre or faire), that is, one's ability to acquire new knowledge of another culture; and
- critical cultural awareness or political education (savoir s'engager), that is, one's ability to evaluate critically practices and outcomes in one's own culture, as well as in others'.

In other words, students arrive in China with various levels of intercultural competencies and "different orientations or predispositions that influence their approach to and performance in the instructional setting" [45].

Studies on intercultural sensitivity and cultural adaptation of international students indicate that intercultural sensitivity (e.g., language proficiency) has a positive effect on the sociocultural adaptation of international students [30,31,60]. Thus, this article integrates the theories of intercultural sensitivity and of the six-stage cross-cultural adaptation to develop a framework that explains the importance of instructional beliefs of international students on university campuses in China. Additionally, it should be noted that, within the context of the two intercultural sensitivity models, this is the first comprehensive framework on the sociocultural and academic experiences of international students in China vis-à-vis instructional communication in the classroom.

The importance of students' cultural characteristics as a first-order variable was established by Akhtar and Pratt [61], who reported that intercultural sensitivity had a significant positive effect on sociocultural adaptation, but a weak effect on academic adaptation. Bringing that strand of research to bear on this proposed conceptual framework means that for international students to overcome academic barriers, a new perspective on sensitivity needs to be adopted and their competencies in the host language assessed. That study described that sensitivity as academic intercultural sensitivity in the Chinese context, which can help to enhance the level of academic adaptation of international students in China. The rationale behind that view is that general intercultural sensitivity only helps in sociocultural adaptation, but seldom offers a solution to the challenges of academic adaptation.

Second, Akhtar and Pratt [61] reported that sociocultural adaptation had a weak impact on academic adaptation while academic adaptation had a strong impact on sociocultural adaptation, which meant, on the one hand, that if international students were satisfied with their academic environment, they could adjust with relative ease to the sociocultural environment. If, on the other hand, they were satisfied with their sociocultural environment but were not satisfied with their academic environment, their overall adaptation to China could be undermined. Furthermore, the students' satisfaction with sociocultural adaptation and with their academic adaptation could enable them to adapt better to a new society. Failure in either case could negatively affect their adaptation to China.

Unlike in Western higher-education institutions, where most international students already have language skills to immerse themselves in the mainstream academic environment, a majority of international students in China's universities arrive without any academic language competency and understanding of China's educational system. Consequently, this lack of academic intercultural sensitivity creates significant problems for international students as they seek to adapt academically in China's universities. Thus, a rationale for the conceptual framework presented in this article is predicated on the broad range of the importance of students' cultural characteristics as precursors to their instructional experience. In other words, if the international students' language competency were minuscule, then instructional barriers would be apparent, undercutting their instructional competence and compromising their overall classroom experience and their adaptation to a new environment: China's universities.

The second-order construct, instructional beliefs, include the students' expectations for success, self-efficacy and empowerment [45], and their Chinese-language instructional competence.

This framework is based on the proposition that a higher proficiency in host-country language will manifest itself in enhanced instructional communication that reduces the likelihood of cross-cultural pragmatic failure and enhances the likelihood of pragmatic competence. It is assumed that those learning outcomes—that is, products of a process—will inform future rhetorical activities of Chinese professors, making instructional communication an action, an interaction, and a transaction: "Instructional communication is the process by which teachers and students stimulate meanings in the minds of each other using verbal and nonverbal messages" [19] (p. 5). It must be noted here that if (Chinese) instructional faculty are tethered to the rhetorical process in a manner that disregards student needs and motivations, then the likelihood that the students' communicative competence will be stymied becomes feasible. Earlier studies (e.g., [38–44]) indicated only English-medium programs' instructional issues and evaluated their challenges; therefore, our conceptual framework presents a more integrated approach to reducing misunderstandings between Chinese professors and their international students in classrooms. This present study is an effort to provide a more culturally sensitive instructional communication in the Chinese context to better accomplish a knowledge-based economy under BRI.

6. Conclusions and Implications of Framework for Sustaining BRI

What are the implications of instructional communication in China in an intercultural context for an innovative, synergistic sustainability of BRI? This article is the first attempt to conceptualize the key elements in students' understanding of classroom material within the context of China's growing multiculturalism in higher education and of its Belt and Road Initiative. Our discussion suggests five major implications of the instructional settings of China's multicultural classrooms for sustaining and broadening BRI.

First, it is important to acknowledge the asymmetrical discourses or unequal encounters between native and nonnative speakers [58] in China's multicultural university classrooms. The implications of such outcomes for learning outcomes need to be better addressed within the context of China's dominant high-context culture. That calls for using the results of an initial assessment of students' awareness of speech acts to develop programs that demonstrably acknowledge the conceptual framework proposed here. But perhaps more than those, the administrators of BRI can be more aware of skills and expertise readily available regionally, if not internationally, as they develop projects for the mutual benefit of BRI partners.

Even though a stock-taking of resources for managing long-term projects is being undertaken by various BRI partners with the collaboration of career-development offices on various university campuses and research centers in China, there is a crucial need to develop programs that specifically require, as Cruz [62] noted, role plays under pragmatic pressure and model dialogues with authentic discourses appropriate in communities of partners. Such participation can place a premium on honing international students' expertise for BRI support and as an indicant of BRI effect in its own right; on enhancing international students' communicative competence; and on reducing, if not avoiding, pragmatic failures that emanate from unequal, asymmetrical instructional encounters. As Bennett's [48,49] linear development model states, there will be a progression in such enhancement, even as it is apparent from Figure 1 that extraneous factors influence the outcome of such a process, ensuring that communication interculturality, which varies from person to person, is not entirely a discretely linear process. Student participants could be provided feedback on their role plays to make them better aware of speech acts and better recognize potential areas of difficulties between their own knowledge and that of a native speaker. But, more important, "students may become aware that their participation in communicative activities may be influenced to some extent by their ... knowledge [of a nonnative language] and sociocultural expectations" [62] (p. 38).

Second, international students need to be more cognizant of the salient features of Chinese culture (e.g., differences in communication habits and in modes of thinking), the environment, and the educational system *before* arriving in China. Inarguably, China's higher-education system is "highly stratified" [63] (p. 30): there are the more powerful and the less powerful universities, the leading and the ordinary universities [64]; the private and the public [25]; the more than 600 universities of applied technology, which have long been engines for research and development, and are being transformed to focus them on "regional economic development by cooperating with local small and medium enterprises in applied innovation projects" [63] (p. 30), consistent with BRI mission; the higher-distance-education programs [65,66]; and the new, all-research university, the Westlake University, in Hangzhou, Zhejiang province. The latter institution, "a cradle of innovative talent in advanced science and technology" [67] and China's first private institution approved to award doctoral degrees, emphasizes team-building and team projects that revolve around discovery through advanced basic research and applied, problem-solving, interactive approaches that are not nearly as embraced by other types of China's universities. Such an institution, can, as Jin [27] observes in private universities, "help usher in new opportunities for social and economic development" (p. 401), consistent with BRI's infrastructural goals and with those of its other development programs.

Granted, even though instructional behaviors in China's university classrooms are not monolithic, they tend to perpetuate characteristics of China's higher education: hierarchical, authoritarian relationships that tend to cast professors as all-knowing and superior to their students, to favor professor-to-student knowledge transmission and to limit teacher–student classroom interaction [68–71]. Such characteristics, therefore, require orientation classes and training workshops offered in and encouraged by China's embassies and consulates worldwide on how to engage Chinese professors dialogically within much-vaunted cultural practices. Additionally, such embassies can provide videoconferencing and computer-assisted training to help incoming students to better adapt to their new cultural milieu. Because most international students are on financial support provided by the China Scholarship Council, it is also recommended that such a government agency, through China's embassies and consulates worldwide, become involved in programs such as orientation sessions that better help students to adjust to their new environment. That way, international students' over-expectations, often based upon misinformation, could be upended, giving way to realistic expectations that would make the students better prepared sociopsychologically for environmental demands and adjustment.

Third, university management of the international student experience [72] and cultural sensitivity training for faculty members are critical to fostering an academic environment that some students perceive as restrictive culturally. BRI, at bottom, is multiculturalism extraordinaire. Consequently, instructional communication—that is, communication for the purpose of engaging students academically and reducing problematic understanding significantly—a bane of the educational experience of international students in China, must be more forcefully addressed head-on from a policymaking perspective. As Chiang [37] notes, "Given that intercultural communicators do not possess the same stock of linguistic and cultural knowledge, problematic understanding is bound to occur" (p. 463). And such problems can engender discontent of international with academic programs. For example, Western students, as noted in a preceding section of this article, usually do not like their Chinese professors' public reporting of student grades, their professors' in-class criticisms of students who fail to answer professors' questions, and their professors' tendency to compare publicly students' grades or learning outcomes [35]. Chen and Starosta [45,46] aver that intercultural awareness, sensitivity and adroitness will enable interactants to reach their communication goals. Thus, training Chinese professors as a matter of academic expediency in a global context requires that they demonstrate knowledge and skill in nuanced communication with other cultures. For example, nonnative speakers of Mandarin Chinese are always advised to slow down considerably in their English-language presentations to their Chinese hosts. Part of that exhortation is justified in part by the time necessary to have a translator on hand navigate between two disparate languages.

Fourth, universities with substantial international student enrollments should provide on-campus orientations in several languages, including Chinese, English, French and Arabic, to incoming international students. Through such activities, the university staff should be able to answer student inquiries effectively. Students should know more about, say, the registration procedures, the local rules, conventions, practices, the environment and the educational system. Universities can provide profound opportunities for domestic–international student interaction and create a friendly classroom atmosphere for international students. One possibility is having rotating theme classrooms: one month, the theme may be Germany; another, England; and yet another, Egypt. Rotating themes can also be campuswide or schoolwide, providing enormous opportunities for students to connect much more easily with one another, to build friendships, and to foster better understanding and to communicate more in, say, Mandarin Chinese.

Finally, it is imperative that China's universities have, as a matter of policy, annual university-wide events that showcase their international stature and interest, but strictly within the BRI context. As of today, such events occur, palpably absent BRI themes. Such events—say, "Global Instruction at Wuhan"—will include domestic and international students' testimonials on personal exchanges on curriculum-related projects, classroom engagements between students and professors, in-class dialogues between international students and their Chinese faculty. Furthermore, partnerships and initiatives will highlight international students' classroom engagement on a multicultural scale.

It is expected that, absent of empirical evidence, the prescriptions outlined here will require additional government support to participating universities. Such investment is justified by the growing and increasing presence of China on the global stage and by the expanding reach of BRI. The Communist Party of China understands full well that the country has expanded its global influence well beyond the Pacific Rim. As Callahan and Barabantseva [73] observe, the country's enhanced global role is being manifested in part in its model of international relations. That model, which informs China's higher-education policy, intersects with BRI, which, in turn, ensures a pivotal role for China's international higher education in sustaining and projecting BRI and for the latter in providing a vast network of resoures to the former.

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How to Retain Global Talent? Economic and Social Integration of Chinese Students in Finland

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Abstract: Global talent is the key resource for today's knowledge-based society and sustainable economic development, and an increasing number of countries are aiming to not only train but also to retain international students as a potential supply of highly skilled labor in innovative fields. This article explores ways to retain international students as global talent through an empirical study on mainland Chinese students' integration into Finland as an example. Based on data obtained through semi-structured interviews with 30 Chinese students, this research identified a number of individual and societal factors that contribute to their difficulties with economic and social integration. The findings demonstrate the complexities of the language barrier faced by Chinese students in non-Anglophone country contexts, and the important interplay between students' social and economic integration. The host environment (nation-states and organizations) also plays a vital role in creating a more open and multicultural environment to enhance the capacity of such young people to integrate and innovate. This paper concludes with a number of proposals for individuals, organizations (including higher education institutions (HEIs), and nation-states to consider for innovating their policies and measures to better integrate global talent.

Keywords: global talent; social integration; economic integration; innovation ecosystem; Chinese student; Finland

1. Introduction

Highly skilled workers increasingly play a central and indispensable role in today's knowledge economy. Through scientific discoveries and breakthrough innovations, talented individuals not only push through new frontiers of knowledge, but also expedite economic development. Developed economies (such as Finland) around the world are increasingly competing for highly skilled migrants, who potentially have better labor market prospects and satisfy the need to achieve global sustainable development [1–3]. Highly skilled migrants boost innovation, which is the key path to sustainable long-term growth and breakthrough performance. To satisfy the needs of environmentally sustainable economic development and the knowledge economy, more and more countries realize the importance of attracting and integrating global talent through an environment supportive of research and innovation [4]. However, the number of potential immigrants with high economic potential who can also easily integrate into the host labor market is limited, and more and more global talent are becoming increasingly selective about career potential and social welfare in the host country [5]. Thus, immigrant receiving countries rely on retaining international students as a source of highly skilled workforce, since the students have earned their credentials in the host society and are expected to be better integrated due to their cultural and linguistic competences. However, many studies have shown that international students face serious challenges to their integration (e.g., [6–8]), which implies urgent need for integration policies to complement immigration policies.

Global talent (or international talent) is generally defined as people with professional knowledge and global skills with potential to generate great values [9]. Global talent can be an international student, a researcher, an accompanying spouse, a work migrant, an asylum seeker, or a returnee [1]. Global talent usually refers to those who hold higher tertiary education degrees, but it can also refer to highly skilled individuals who have high expertise in a certain field. For organizations, global talent management generally includes different organizational activities for attracting, selecting, developing, and retaining the best employees in the most strategic roles on a global scale [10]. In this research, global talent specifically refers to international students pursuing degrees or young researchers conducting research in countries other than their countries of origin, since they are potential innovators or entrepreneurs who are critical to contribute to breakthroughs in technology, knowledge, and modes of new production [11].

The integration of international students as global talent is important for a number of reasons for the knowledge-based society and sustainable economic development. First, global talent are key actors in building the transnational innovation ecosystem. The transnational innovation ecosystem is generally defined as the transnational integration process of two or more innovation ecosystems [12,13]. It builds on the concept of innovation ecosystem, which is characterized by co-evolution of different collaborative actors that develop interdependency over time for sustainable development [4,14,15]. Since international students have the socio-cultural and business-related knowledge and network with both home and host countries, they can be an important link in fostering trust between various actors in the transnational innovation ecosystem. In transnational contexts, more distance between the collaborators and more sophisticated institutional structure requires global talent with an understanding of two or more cultures to build trust for successful research and innovative cooperation.

Second, skilled persons including students and researchers have been incorporated into the "sustainable development" strategies of institutions, regions, and nation-states [16]. Due to the increasing link between the knowledge-based society and a growing public awareness of the need for environmentally sustainable development [4], global talent, including international students, become a valuable resource to be tapped. Promotion of the mobility of students and highly skilled professionals is outlined in the Europe 2020 strategy for a smart, sustainable, and inclusive growth in a global economy [17]. As Chinese students are one of the largest groups of international students around the world, many higher education institutions in Europe are relying on attracting them for their own fiscal sustainability. The report on EU-China student and academic staff mobility clearly states that many European universities face the challenge in "ensuring sustainable market growth in a mature market." Students especially are increasingly seeking globally, for education that ensures a good value of return for their investment, in terms of money, quality, and institutional reputation [18]. Meanwhile, the mobility of Chinese students presents both an opportunity for EU countries to retain as high skilled labor, and a sustainability challenge for China due to the problem of brain drain. To maintain and nurture the sustainable knowledge network, both EU and China have been designing competitive and sustainable knowledge network and international partnership for mobile academics, institutions, and broader societies [16].

Third, a substantial body of literature has shown that many countries have enjoyed net innovation and productivity gains as a result of talent inflows, with the United States being the most studied and prominent case [19]. Highly skilled immigrants boost innovation and productivity through the increased number of individuals pursuing innovative work, while transnational innovative collaboration boosts the revolution of the global innovation ecosystem. As more and more developed societies around the world are seeking high-potential global talent to boost their knowledge-based economies, international student mobility and international experience are promoted as key to knowledge transfer and sustainable development. [20]. Thus, international students who are equipped with international experience and an internationalized curriculum are ideal candidates for many countries to compete for to support their high skilled labor market demand.

Fourth, international graduates have better potential of economic and social integration than highly skilled workers recruited directly from abroad. Besides saving on the relocation costs, the benefits of recruiting international graduates also include: Proficiency in the local languages; capability to build transnational professional networks, and understanding of the socio-cultural and business-related aspects of home and host countries [19]. Previous research suggests that students might have less incentive to return to their countries of origin, because they spend important life phases, for building friendships and relations or starting families, in the host country. Those relations will develop into personal attachments in the host country and can result in fewer incentives to return than highly skilled workers who built their social network before moving to the host country [7].

Finland only joined the global race for highly skilled professionals in recent decades. With its economic development spurred by technological development, Finland has changed from a country of emigration to one of immigration, and has sustained its focus on economic development based on technological advancement and sustainable development. Due to its increasing demand for highly skilled workers and the projected aging population leading to a diminution of the working age population, Finnish immigration has continued to open up its policy to recruit and encourage international students to stay to find work or start businesses after graduation. Initially, international students were only allowed to stay for six months to seek employment after finishing their tertiary education in Finland. However, ever since 2015, such students are allowed to stay to find work for up to one year following the completion of their studies [21]. A recent report by the Finnish government suggested good practices of government models to incorporate global talent into the Finnish innovation economy, and proposed a long-term vision that "Finland has attractive, inclusive and sustainable innovation ecosystems that thrive from diversity" [1]. To achieve this goal, it suggests having "both public and private stakeholders on board and financially committed," to develop sustainable funding and business models and incentives for demonstrating impact (ibid.).

Despite the explicit policy and agenda to attract and integrate international students as global talent in the labor market, studies on whether and how international students integrate into the host society, if planning to stay in the country remain scarce. Many of the studies have focused on the drivers of international students' mobility and the experience of studying abroad (e.g., [22]). In general, less attention has been paid to the integration outcomes of the international students beyond academic contexts, especially their study-to-work transition [23]. Nevertheless, a small number of studies can be found showing that economic and social integration of international graduates aiming to remain in the host society can be difficult to achieve (e.g., [24,25]). However, these studies mainly focus on international students' experiences in Anglophone countries, while non-Anglophone country contexts deserve more scholarly attention since the local language can pose additional challenges to international students' integration. Meanwhile, since countries like Finland are aiming to retain international students as highly skilled workers, it is also crucial to understand how the students integrate into the societal contexts if they plan to remain after graduation. This research aims to fill in the gap by exploring the following questions:

RQ1: How do Chinese students integrate economically and socially into the host society if planning to stay in the country?

RQ2: What are the individual and societal factors that affect the economic and social integration of Chinese students?

Given the large and growing percentage of overseas Chinese students and scholars who study abroad, their integration into the local society has become an increasingly pressing issue. A number of studies in the context of other countries have demonstrated that good integration can be difficult to achieve (e.g., [26–30]).

2. Literature Review and Analytical Framework

Although there is a lot of literature dealing with student integration, these studies mainly look at the issues from a narrow perspective. There is an urgent need to generate a comprehensive understanding of the term and phenomenon through synthesizing the literature. While the term 'integration' is frequently used in different fields of literature, its meaning can be quite different in different contexts. Building on the conceptualization of integration provided by International Organization for Migration

(IOM) [31], I define it as follows: A bidirectional process of mutual adaptation between the host society and migrants (in this case international students) themselves, both as individuals and as groups. As this definition suggests, students' integration cannot be achieved purely by individual or group effort, but rather requires a combined effort by multiple stakeholders, including students, educators, university administrators, employers, and policymakers. From the host society perspective, it also entails a more receptive and welcoming environment that incorporates newcomers to become part of the enlarged membership in the host community, while allowing newcomers to maintain their ethnic and cultural heritage [32].

As theory is central to enhance our understanding of the world, the current research finds the most appropriate theoretical perspective for analyzing the current research topic is the structure and agency approach. Structure is often referred to as objective social institutions that affect the way people act and live, while agency is usually referred to as human choice, action, and deliberation. This brings in the paper by Tholen [33], in which he discusses the interplay between agency and structure through empirical investigation of graduate employability. Tholen (2015) proposes that graduate employability is not solely individual phenomenon, but structured by inequalities and opportunities within the structural context, and influenced by the labor-market hierarchy. Meanwhile, individuals' identities also decide their competition strategy for jobs. Some studies point out that an individual's labor market decision is not solely economic calculations, but choices are also based on their ethnicity, class, gender, life history, and other backgrounds (e.g., e.g., [34,35]). Thus, understanding of international students' integration in the host country requires a contextual analysis of both, since individuals' agency is embedded in different contexts where social relations are constituted and negotiated. However, this does not exclude individuals who have the capability to rebel against existing social structures, especially in circumstances where certain groups dominate other groups by utilizing their position within society, or forms of capital or scarce resources [33].

Although the main aim of the current research is to analyze the students' integration into host society as global talent, which centralize the importance of economic integration, social integration also constitutes an integral part that influences and shapes the integration trajectory. Previous research [26] highlights the importance of understanding the interplay between different domains of integration, that economic and social integration are influential and endogenous for each other.

In sum, adopting the theoretical approach of agency and structure, the current research mainly examines students' economic integration through two domains, namely individual and societal factors. In addition, the relations individuals have also influence how they interpret, react, negotiate, or resist existing societal structures. Therefore, social integration is incorporated as another domain to examine its interplay with economic integration, and to offer a more comprehensive understanding of student integration.

2.1. Economic Integration

The term economic integration is defined in general as the migrants' process of joining in economic participation or finding and retaining job opportunities in the host country's labor market [36,37]. Within the field of higher education, it is often referred to as 'employability' in some literature, which Shumilova and Cai [19] define as a graduate's ability to find work, which is influenced by employers' beliefs and other contextual factors. It also involves a 'psycho-social construct' that combines with other individual characteristics to ensure individuals maintain work in uncertain economic environments [38].

2.1.1. Individual Factors

Past research shows that although international students are prepared to function as global talent with intercultural savvy and job related skills [39], and who may potentially be more employable than local graduates [40,41], the reality is often not as expected. International graduates are often more vulnerable [42] and face more challenges in the labor market than do local graduates [43]. From an individual's perspective, when international students are seeking employment in the host country, especially where the local society is more homogenous, ethnicity can be an important factor that causes some foreign graduates to face discrimination when applying for a job [44,45]. Access to professional networks also plays an important role since foreign job seekers may well lack professional ties to help them find work and local employers may have reservations about hiring foreigners. Those who are recommended by a previous employer or people that they know may have a better chance of being hired [46]. Studies conducted on international graduates' employment [43,47,48] identified a number of challenges they face, including restrictive immigration policy, lack of professional networks, family reunion issues, language barriers, racial discrimination, etc.

2.1.2. Societal Factors

International students' economic integration does not merely depend on individual competencies and agencies, but also on structural contexts, namely societal factors, such as the prevailing labor market situation, employers' perceptions and needs, relevant government policies in the country, etc. [49–51]. From a government and employer perspective, there seems to be a paradox in the recruitment of foreigners. On the one hand, the national agenda in many countries has emphasized the importance of retaining foreign talent. However, the legislation in the EU and at the local level still protects the rights of local and EU citizens in such a way that employers should prioritize hiring their own citizens, then EU citizens, and finally non-EU/EEA (European Economic Area) citizens [1,52]. Foreign applicants may face discrimination from potential employers. For instance, the Eurobarometer survey shows that 52% of Finnish employers mentioned that when choosing between two candidates with comparable qualifications, one's ethnic origin and skin color could put a job applicant in a disadvantaged position [53]. Although nation-states and organizations (including universities) are increasingly aware of the importance of retaining international graduates and supporting their economic integration, they still see the primary responsibility as resting with the individual [49].

2.2. Social Integration

Building on the conceptualization provided by Ware et al. [54] and Spencer-Oatey [24], social integration is defined as the process through which individuals develop their interpersonal networks and involvement in communities. Social integration is an ongoing process involving not only social interaction between individuals but also involvement in groups and communities. It can refer to students' social activities in academic settings, such as meeting formally or non-formally for academic work, or in non-academic settings, such as involvement in social activities, building friendships with each other.

Studies in higher education have also pointed out that social integration helps with better academic integration [28,55] and student well-being [56,57]. Three types of networks were identified by Bochner et al. [58]: Co-national networks with people from the same ethnicity or countries of origin; host-national networks with people from host society; and multinational networks with other international sojourners. Past research has repeatedly documented that stress, culture shock, loneliness, and homesickness can be a problem particularly for international students (e.g., [57]. A number of studies have reported that networks and friendships between international and domestic students contribute to lowering stress, alleviating loneliness, enhancing psychological well-being overall [59]. However, local and international students have difficulties integrating well with each other (e.g., [26,60]. A number of obstacles have been identified, including cultural differences, language and communication difficulties, different learning styles and/or lifestyles, lack of common social groups, or lack of common interests [24]. The co-national networks can be important for enhancing students' social integration, since having peers with similar linguistic and cultural backgrounds also helps alleviate the stress of integrating to new environment, and provides essential psychological and social support [61]. However, exclusive engagement with co-nationals can also inhibit students from forming networks with the host-nationals, acquire the cross-cultural communication competency, acquiring or improving linguistic skills [61].

A review of existing literature reveals four gaps: First, existing research on students' integration mainly examines their integration in academic contexts, while their integration in the broader societal context as migrants is less studied. Meanwhile, research on economic integration of foreigners in the countries of immigration generally focus on types of migrants such as refugees, family migrants, or economic migrants; less attention is directed on international students' integration into the host society, who came to the host society first as a student and have different integration trajectories than other types of migrants. Second, the research on students' economic integration (or employability) often addresses the students' own characteristics and competency, as well as institutions' (such as higher education institutions) assistance with students' transition to the labor market; there is less discussion about the societal factors that can facilitate or hinder foreigners to compete in the labor market. Third, less research has addressed international students' economic integration and social integration collectively to explore how they influence, enhance, or inhibit each other. Finally, less research so far has addressed international students' integration in non-Anglophone EU countries, if they plan to stay after graduation. Thus, the current research aims to fill in these gaps through the empirical study of Chinese students' integration in Finland, and shed light on how non-Anglophone countries like Finland can address existing issues to retain more global talent to build sustainable innovation economy.

3. Methods and Methodology

A qualitative research design is used in this research, in which data were analyzed through thematic analysis, which allows the researcher to focus on research questions when analyzing the data. This research draws on data collected through semi-structured interviews with 30 mainland Chinese tertiary students who pursued degrees in Finnish higher education institutions (HEIs) from 2015 to 2016. An interview is where 'knowledge is constructed in the interaction between the interviewer and the interviewee' [62]. This study uses interview as a research method because it allows the researcher to guide the research participant into the topic and obtain more in-depth information through interactive conversation. As a qualitative study, the purpose of this research was to achieve a nuanced understanding of the Chinese students' economic and social integration experiences and the meanings they attached to those experiences. Choosing interview as a method enabled the participants to talk freely, consider the question deeply, and offer opportunities to follow up on issues deemed as important or emerging from the interactive conversation [63].

The current research used two methods to recruit interviewees: First, the researcher contacted international offices of HEIs across Finland to send out research invitations to existing mainland Chinese students. Second, the researcher sent out invitations through online social platforms such as Wechat, Facebook, Weibo. Later, snowball sampling was also used to encourage research participants to recruit potential research participants through their friends. Permission to collect data from the research participants was approved by the Ethics Committee of the Tampere Region, Finland. Both Finnish universities and universities of applied sciences are included in this research, and interviewees are located in most of the major cities in Finland, such as Tampere, Helsinki, Turku, Oulu, etc.

Research respondents in this study include 18 female and 12 male, with various backgrounds in terms of major of study, age, pre-migratory study and work experience, duration of residence in Finland. Such variety of study, pre-migratory experience, and duration of residence allows the researcher to explore the research respondents' integration aspiration, experience, and future goals in different phases of integration trajectory.

The interviews were conducted in Mandarin Chinese by the author, and generally lasted from one to three hours. The common cultural and linguistic background allows the interviewees and interviewer to create a relaxed atmosphere and engage in open conversations [64]. All interviews were audio recorded (with written consent from the participants), and later transcribed and anonymized for qualitative data analysis.

This research adopts a thematic analysis to identify patterns in the interview transcripts [65]. The thematic analysis followed four typical stages:

First, the transcript is read and familiarized, main themes and thematic codes are generated both deductively from the literature review and inductively from the data to capture the essence of the interviewees' experiences.

Second, for each theme unique to a group, a statement is written. This statement is condensed to a label, and the label becomes a code. Initial codes were generated and used for coding the data, while open coding is performed simultaneously. Either one sentence or one paragraph is the unit of analysis for coding, and multiple codes can be used for one sentence or paragraph. The coding process involved constant review and rewriting the codes for applicability to the data.

Third, a number of sub-themes and sub-codes were identified. The established sub-codes were grouped under the main thematic codes, re-defined during the coding process, and applied to the remaining data.

Fourth, the inductive and deductive analytical interpretation of the data is presented.

The line-by-line coding process used mainly manual coding strategy and NVivo 12. The data analysis process revealed four main themes for students' integration in the host society: (1) Individual factors affect economic integration; (2) societal factors affect economic integration; (3) social integration; and (4) measures for improvement. These main themes were divided into sub-themes, as shown in Table 1.

Table 1. Analysis categorization system and coding.

Main Themes		Coding
Economic Integration	Individual factors	• Language issues • Job-related skill and field • Family reunion concern • Communication skills
	Societal factors	• Unequal work opportunity • Career development glass ceiling • Uncompetitive salary/award system for high-skilled talent • Foreigners fill in niche job market
Social Integration		• Lack of deep contact • Lack of professional network
Measures for Improvement	Individual	• Mentality and attitude • Entrepreneurial job-seeking approach
	Structural	• Internationalization of Finnish work environment

In presenting the findings, no personal data is disclosed that may cause the interviewees to be recognized. The anonymity of respondents was protected by using only gender and university subject major to characterize the respondents. Citations from the interviews conducted in Mandarin Chinese were translated into English by the author. In addition, an internal expert who was familiar with the research offered comments on data analysis and translation process.

4. Findings

4.1. Economic Integration

4.1.1. Individual Factors

Chinese students who studied in the Finnish universities have varied aspirations to stay in the host society after graduation. Some of them would like to remain in the host society for family reasons, others would prefer to stay in the host society due to their preference for the socio-cultural environment of the host society. Despite their varied reasons for wishing to stay, they shared a common understanding that the utmost important aspect of integration was finding suitable job opportunities and having networks with the local people, while finding employment was often mentioned as the top priority. However, the interviewees also shared the same feeling of frustration due to the difficulties of finding jobs in Finland. For instance, one of the interviewees said in her interview:

> Interviewee: Of course, I want to become integrated into Finnish society, but it is not so easy! For people like me, finding a job is the first and uttermost problem. When you do not have a job, your social circle will be very small and limited. Basically, all you are interacting with are Chinese people. For instance, people like my neighbors who are neither studying nor working, then all their networks are Chinese. How do you integrate into Finnish society in such a case? Finnish people are not so open that they are easy to make friends to begin with [. . .].
>
> Interviewer: Why do you think it is so difficult to find jobs?
>
> Lin: First, (it depends on) your field; second, language skills; third, I do not want to be so straightforward, for instance if you are as good as other Finnish candidates, who do you think they would recruit? Of course, they would recruit the Finnish candidate.
>
> (Female, mathematics)

(1) Language issues

If Finland is to train and retain more global talent, it remains debatable whether international students aiming to stay on after graduation should invest more time to learn a skill that is highly valued in the labor market, or spend time to learn Finnish. Since Finland is a non-Anglophone country, the local language can pose a great challenge to Chinese students' integration both economically and socially. A number of studies have noted the importance of language skills for migrants' integration (e.g., [66,67]). According to earlier research, the conclusion always seems to be that international graduates who wish to stay in Finland cannot easily find suitable jobs due to their limited Finnish language skills (see for instance [47]). One of the interviewees said:

> Finnish language is one of the main obstacles. Taking some Finnish language course can never qualify you to do what a Finnish native can do.
>
> (Female, statistics)

Since most students came to study in Finland in English-taught programs, this research found that the majority of the students had not yet acquired fluent Finnish skills to enable them to work in Finnish before graduation. Among all the interviewees who participated in this research, only two people spoke relatively fluent Finnish and they were able to work in Finnish—both of them majored in Finnish studies during their bachelor's studies. However, contrary to the traditional view that Finnish is the major obstacle to their economic integration, some interviewees argued that being able to work in English was enough. For instance, one of the interviewees said:

> If you ask 100 Chinese people who are working in highly skilled positions in Finland, I believe most of their working language would be in English. Maybe 60 to 70 percent of them use English at work. I can only say that if you know Finnish, it helps you to understand their ideas, local and corporate culture as well as society, which will be a plus, but it is not a decisive factor.
>
> (Female, higher education)
>
> Another interviewee also expressed similar ideas:
>
> Interviewer: When you say they have good language skills; do you mean Finnish or English language skills?

Interviewee: When I say language, I mainly mean English. Because as a foreigner, when you are trying to find a job in Finland, I think most of the people will be mainly working in English. Whether your Finnish is good or not is not the decisive factor. Your English, even though not perfect, must be clear and lucid when you try to express yourself. You need to be able to use English to express in-depth thoughts. [...] Because no matter how good your Finnish is, it will never be as good as Finns, right?

(Female, marketing)

(2) Job-related skill and field

Several interviewees expressed their opinion that being highly skilled in a field that is highly demanded in the Finnish labor market might be more important for job seeking than investing all the efforts to study Finnish. For instance, several interviewees mentioned that being highly competent in technical fields such as data analytics and programming often open doors for many job positions. In addition, one interviewee mentioned that there seems to be a lack of nurses and care workers in Finland. For instance, one interviewee from an IT background expressed the opinion that his job-related skills were far more important than his knowledge of the local language.

I think if you are good enough in your (major-related) skills, you can find a job anywhere. [...] For us who study computer science, even if we are facing someone who does not speak English, we can still read each other's code, right? That is why even if I learn Finnish really well, if I am not good enough in my professional skill, I still cannot find any job.

(Male, computer science)

Clearly, this research shows that in a non-Anglophone country, both the local language, Finnish, and also English mediate the students' integration to different extents. Furthermore, the findings of this research challenge the traditional view that lack of Finnish skills is the major barrier that prevents students from becoming employed. Since the international graduates are competing in the highly skilled labor market, their skills may often be the most valuable asset to be competitive in the Finnish job market, while Finnish language skills may be an additional advantage.

As more and more Finnish companies and institutions are operating internationally, English is more and more accepted as a working language. Thus, it may be advisable for students to explore the local job market situation to see which sectors have higher demand for international workers so that they can set clear goals for their careers and strategies for their future employment.

(3) Family reunion concerns

Another difficulty for integration and long-term settlement in Finland mentioned by some of the interviewees was concern about family unification with their parents. Currently, the Finnish immigration policy only recognizes nuclear family, which consists of spouses and their children. However, many Chinese overseas students will face the challenge of taking care of their parents when they are older if they decide to settle down in Finland. Once of the interviewees said:

If Finland hopes that more outstanding Chinese highly skilled workers will settle in Finland, how those people can take care of their parents if they decide to live here is a big issue. Because we are the single-child generation. According to the current migration policy in Finland, our parents cannot come to live here. They can only come every year for a maximum of three months. When we are still young, it is not a problem. But what are we supposed to do if we are older and our parents need to be taken care of extensively? Then we have to give up (living here) ultimately, right? Because Chinese parents and children are very close, and as a single child one cannot leave one's parents at home when they are old. I think that Finland should allow those with permanent residence permits and type A visas to bring their

> parents here without providing any social benefit. Thus, the children can be reunited with their parents and solve many issues.
>
> (Male, artificial intelligence)

(4) Communication skills

In addition, some interviewees also mentioned that communication skills are also very important, since they would need to fluently, confidently, and logically 'sell' themselves to the employers. After the intercultural adaptation process in university, it is also very important for the students to be confident to express themselves in various multicultural settings, since the students are expected to work in multi-cultural work environments or international projects that they would need to act as a cross-cultural communication bridge. One interviewee said:

> I think some students are not good at communicating or expressing themselves. They have a lot of ideas but do not know how to express logically with key points. Another issue is that many people are not confident with themselves. They always feel they are not good enough, or think that other people will discriminate against them. [. . .] But those people who found jobs are basically very confident and self-assured.
>
> (Female, MBA)

4.1.2. Societal Factors

(1) Unequal work opportunities

From the interviews it is clear that, besides individual factors, there are also societal factors that contribute to the students' difficulties with integration. Many interviewees said that they did not feel that they had the same opportunities and access to valuable resources (such as job opportunities) as the native Finns. Some positions might require job holders to speak fluent Finnish, which in some ways can be used to exclude foreigners. When asked about equality of job opportunity for foreigners, almost all the participants said that they did not think they had the same opportunities for finding jobs or promotion as native Finns, one of the interviewees said:

> Interviewer: Do you think we have the same opportunities for finding jobs and for promotion like Finns?
>
> Interviewee: For sure we don't have the same opportunities (for finding jobs and job promotion). You have to be much better than the Finns, and not just a little bit better. For the same job, if a Finn can do it, you need to be much better (in doing it), and bring much more value, this is obvious. (There is) inequality in finding job opportunities, and also seeking for promotion. Although theoretically, this is an equal society, but in reality, it is not equal. Finding job opportunities (for foreigners) is the biggest challenge.
>
> (Male, signal processing)

Some interviewees aiming at an academic career expressed similar feelings of exclusion from opportunities in academia:

> For instance, when they try to recruit people, and if you are more or less at the same level as other, Finnish applicants, who do you think they would recruit? Of course, a native Finn. If your Finnish is not good enough so that you can use it fluently to teach, then of course they would consider Finns, because most of their students are still Finnish students. Of course, the native people will have more advantage. [. . .] Unless you have something extra to bring than the Finns, right? Unless you are really good at doing research. Otherwise why would they hire you and set up English-taught courses (instead of Finnish-taught courses) due to the fact that you are hired here.
>
> (Female, mathematics)

Since it only recently changed from a country of emigration to immigration, preference and trust for hiring from the native population is quite common. Finnish and EU legislation also clearly stipulate that the member states' employers should first consider hiring local people, then EU citizens, and finally non-EU citizens if they are not able to find people of satisfactory qualification in the local job market [68]. It is also due to linguistic and cultural concern, because although people can speak English, communication would still be easier and more efficient in Finnish. Thus, unless the work environment strongly demands internationalization, many jobs will prioritize the hire of Finnish people. For instance, one interviewee said:

> I submitted a lot of applications, but I rarely got any interviews, only one in a year. I went to the university careers service and they said my resumé was impeccable. I think, to be honest, even for technical jobs, they would still prefer to hire natives to work in Finnish. Because if they speak the same language, the work efficiency will be much higher. That is why even if your resumé is so outstanding, your project experience is richer, and your grades are good, they would still not hire you, and finding a job depends purely on luck. If their team are not all Finnish, if they have one foreigner and they begin to work in English, then they wouldn't mind hiring another one.
>
> (Male, computer science)

(2) Foreigners fill in niche job market

Several interviewees mentioned that highly skilled foreigners tend to fill the niche job market that native Finns either do not want to do, or are not skilled enough to do. Another interviewee also shared the same feeling of marginalization. It seems that from her point of view, some of the recruitment practices only favor Finnish applicants, and foreigners have less chance except by filling in a market niche that native people are not interested in. It seems that such recruitment practices can both result from a linguistic and cultural preference that the employers prefer to work in their native language and with people from similar cultural background. She said in the interview:

> I don't think that I have the same opportunities for finding jobs/seeking promotion as the native Finns. It seems that we can only work in the fields where the native Finns are not interested to work. For example, statistical analysis seems to be one of my limited options. And this field attracts few, if any, Finnish educational researchers. I based my assumption on some real experiences. [. . .] In one of the international projects that I got to know at its start, there was a vacant post-doc position which seemed to me very relevant to my husband. When I suggested his name to the project director, he said clearly that this position cannot be offered to a non-Finnish researcher.
>
> (Female, education)

However, another interviewee expressed her understanding for such practice, since recruiting foreigners might impose unforeseeable costs and risks for the Finnish employers, including the added communication costs for using English instead of Finnish for internal communication. Lack of an existing multicultural working environment also makes employers hesitant towards hiring foreigners. She shared her opinion on the potential conditions under which Finnish employers would like to hire a foreign worker:

> On many occasions, when they want to recruit a foreigner such as a Chinese student, there must be at least three reasons. First, either they want to get into the Chinese market and they need someone who understands the Chinese market and culture, right? Second, because this person can bring extra value (more than the Finns). Third, it's because they have such a policy that the project itself requires hiring people of international background. Otherwise, they wouldn't just hire a foreigner (over a local person).
>
> (Male, MBA)

(3) Career development glass ceiling

In addition to unequal opportunities to find jobs due to employers' strong preference for native people, many interviewees also mentioned that they were concerned about their career development in Finland, since they already see the career development glass ceiling if they plan to remain in Finland. For many PhDs who are conducting research in Finland, the scarce chance for obtaining a permanent position is a huge disadvantage for their future career development. For instance, one interviewee said:

> There are limitations for career development in Finland, since it is a small country with limited job opportunities. Many positions, you cannot make it unless you are a Finn. [. . .] As you see, university professors are almost all Finns. Rarely any foreigner makes it to professor, no matter how good you are. Or even if you are a professor, you cannot make it to department head, dean, or university rector. The local societal structure already determined that those positions are only for Finns. And if you look at many Chinese's professions, they are obviously just low-level technical migrant workers, right? Rarely do they make it to the managerial level in Finnish companies. This is an invisible glass ceiling. For people with ambition, this is a huge set-back.
>
> (Male, computer vision)

Another interviewee also expressed similar opinion:

> For instance, one of the professors at the university once said to me that finding a tenure track position (after completing a doctorate) is likely to be exclusively reserved for Finns. Alternatively, he suggested selecting a post-doc position because for this option there are some organizations that can support non-Finnish applicants.
>
> (Female, mechanical engineering)

In addition to career development glass ceiling, several doctoral student interviewees mentioned that there is lack of opportunity for them to develop their career during their studies. Since teaching skills are often required for finding jobs, their current host institutions do not open enough English-taught courses for them to teach. One interviewee said:

> I tried many times to ask my faculty whether I could teach some courses, but I never got any opportunity to teach any course in the faculty. But the other Finnish doctoral researchers seemed to have no problem finding courses to teach.
>
> (Female, medicine)

(4) Uncompetitive salary/award for high-skilled talent

Some interviewees also said the high tax system and high living cost resulted in lower salary for high-skilled talent in comparison to other regions in the world, such as North America and East Asia. Since Finland is a high welfare state, the tax imposed on salary is therefore relatively high compared to other countries. Meanwhile, some interviewees also said the reward system for highly skilled talent who have high research output is also limited.

4.2. Social Integration

(1) Lack of deep contact

A lot of the interviewees recognized the importance of having Finnish friendship contacts and networks if they really wanted to stay and integrate into the local society. However, they also described the difficulties of establishing deeper friendships or contacts with local people. One of the interviewees said:

> I think it's not so easy to become friends with Finns. Because not everyone is so open-minded that they would like to be friends with you. Sometimes they would only say hi if you meet in the neighborhood or something. Even if you have a job here, like (someone's name), but how many of your Finnish colleagues can become friends to have further contact after work, right? I think, first of all, there is a cultural difference. Second, you might need to have something in common with them, like a common hobby. And especially for us it is quite difficult to find a job. So, if you don't have a job, your social network is quite narrow.
>
> (Female, sociology)

(2) Lack of professional network

Despite the difficulties, the participants emphasized the importance of forming networks with local people as they open doors for the interviewees to understand local culture, establish contacts, and potentially find job opportunities in the host society:

> I often receive a lot of invitations to networking events. I know that a lot of Chinese are not interested in joining those networking events. They feel uncomfortable about it. In fact, from participating in those events, I got a lot of useful networks. Those are things that help you to sow the seeds for your future in this society.
>
> (Male, media studies)

This study also confirms that having a local social network will help students alleviate their loneliness and homesickness as suggested by earlier research [59]. Having someone who could recommend them for certain job positions sometimes is much more useful than submitting their job applications online. One of the interviewees said that she managed to find a job due to a recommendation from her Finnish work mentor, who put her in touch with another employer through the mentor's personal network. One of the interviewees stressed the importance of reaching out proactively to the local society. She said:

> If you decided to stay in Finland, then you must proactively integrate into Finnish society. Finnish people are like 'Jing Fen' ("jingfen", or "spiritually Finnish," a term that became popular on the Chinese internet, which is inspired by a comic from Finland called "Finnish Nightmares," describing the kind of people who prefer minimal social contact and avoid social situations), right? They will not actively seek to establish contact with you, if you don't try to communicate with them, you will never integrate. For me, there are two ways to integrate: The first is to study this country's language and culture. I started learning Finnish myself and to subscribe to the local Helsinki newspaper. In the beginning, I was reading an English version of that Helsinki paper. It gave me a lot of help to understand what was happening in Finnish society. I have continuously subscribed to this newspaper for around two years. It helps me to learn the language and to study Finnish culture. The second is that I try to establish networks with the local society. For a foreigner, there are so many difficulties to overcome, like finding jobs, going to see doctors, giving birth to children. If you do not ask other people to help, nobody will help you. [. . .] Previously, I was working part-time for my employer, and established good networks and gained their trust. That is how I got the job that I am doing now.
>
> (Female, education)

4.3. Potential Measures for Improvement

(1) Mentality and attitude

One interviewee mentioned having a proactive attitude, self-confidence, and other valuable qualities that the individuals can adopt can help to improve their chances of being employed:

> Those who can find jobs, first they must be brave enough (not afraid to lose face) to some extent, and second, have good language skills, be confident and honest. Or they have some good friends to recommend them, or they have done a lot of voluntary jobs without payment.
>
> (Male, law)

(2) Entrepreneurial job-seeking approach

Although faced with many uncertainties and difficulties in finding jobs and potential discrimination in the Finnish labor market, one of the interviewees still said that she thought an individual's effort and determination to create a position for themselves is quite important for their own integration in Finland. She provided a potential strategy for those who are struggling to integrate, especially into the labor market:

> I think when you met difficulties in (finding jobs), first, you must not avoid the problem. Second, you should not just complain every day about the social injustice or unequal opportunities for foreigners. You should just face the situation and find solutions. Don't overlook the power of habit. [...] I have another idea (for those who want to stay here): Even if some companies they do not have a specific position to open the market in China, and do not want to be international, I think you should have an entrepreneurial spirit to create positions for yourself. You can give them some ideas and lead them to think that they need to develop in Japan or Korea or China. When they see the potential value of your capability (to open up the Chinese market), maybe they will be able to provide a position for you to try. [. . .] I think when there is no suitable position, you need to create the position yourself. [. . .] I think that a strong will and determination are very important.
>
> (Female, higher education)

(3) Internationalization of Finnish work environment

Some interviewees also mentioned that if Finnish society is to retain more global talent, it is not enough that they try to teach Finnish to newcomers. For highly skilled workers, they might also be highly mobile that they can also find work in other places around the world. Finnish society and working environment should also change to become more multicultural and use English so that they can make the newcomers feel at home. He said in the interview:

> I think Finland needs to cultivate a more multicultural environment for highly skilled migrants and all the people. It is not enough that they only just provide Finnish courses for foreigners. I think a multi-cultural environment is seriously lacking in Finland. A lot of things and information are too oriented or focused on serving Finnish people, because a lot of information is only available in Finnish. But, they realized that if this country is to develop itself, it cannot only rely on Finnish, it needs new blood to enter into its system. Then how do you make those newly arrived people feel at home? I think they should convert more content into English and use English more often in meetings for the international employees.
>
> (Male, electric engineering)

5. Conclusions

This article demonstrates that as more and more countries are transitioning to a knowledge-based society and environmentally sustainable economy, attracting and retaining international students as global talent for boosting innovation rank high on the national agenda. International graduates have the linguistic and socio-cultural competences from both host and home countries, and are potentially an important link in building and sustaining a transnational innovation ecosystem. However, the paradox persists when it comes to practice at the local and institutional level. As the case study based on

Chinese students' economic and social integration clearly illustrates, Chinese students face a number of challenges in their economic and social integration if they plan to remain in the local Finnish society after graduation. First, from an individual perspective, Finnish as the local language poses a significant challenge to their integration since most students came to study on English-taught programs and thus did not acquire fluent Finnish before graduation, while many employers would prefer to hire workers capable of working in Finnish. Lacking professional networks, which potentially result from lack of social integration with the local people, also led to difficulties in finding jobs among the interviewees. As the one-child generation, they also faced the concerns of a restrictive immigration policy preventing them from bringing their aged parents to take care of if they decided to settle down in the host society. Second, from a societal perspective, Finnish society and also employers are yet to become more open and multicultural to incorporate more foreigners into the Finnish working environment. Most of the interviewees reported not having the same access as native Finns to job opportunities or promotion. Such structural exclusion and marginalization of foreign highly educated workers may detract from such workers' desire to remain in the host society, and jeopardize the national strategy of retaining global talent.

This research identified three implications for students and other stakeholders: First, given the discussion on the language issue above, is it better for students to invest time and effort in acquiring skills highly valued in the labor market or in learning the local language? There seems to be no definite answer to this question, since the labor market demand is contextual and varies from one field to another. However, the interviews in this research suggest that, as highly skilled migrants, the students' job-related skills may be their most important asset with which to compete in the local job market. However, having local language skills besides their mother tongue and being fluent in English will undoubtedly be an advantage in their job seeking processes.

Second, while the students encountered numerous challenges during their integration processes, the current study suggests that the students may need to be more proactive and innovative in their economic integration strategies. This finding is consonant with the research by Cai (2014), which suggests that Chinese students can adopt an entrepreneurial job-seeking approach, that a job-seeker make proposals to potential employers by identifying their needs and utilizing their own special skills and talents to create a position for themselves. Besides possessing the hard skills, the students' soft skills, such as being confident, honest, and cooperative team players, can also play an important role in enhancing their economic integration.

Third, given the various societal barriers faced by Chinese students during their integration, should HEIs and local employers become more multi-cultural to accommodate and retain the global talent? As the present study suggests, integration should be a bi-directional process entailing migrant and host societies' mutual adaptation, both as individuals and as groups. The present findings suggest that Chinese students still face a certain degree of exclusion, not only from potential academic opportunities in the host HEIs, but also from the labor market and society more generally. As Finnish society is becoming increasingly aware of the importance of training and retaining international students as global talent, it can be argued that demanding that only the newcomers 'integrate' is not enough. The host environment (nation-states and organizations) also need to be more open and multiculturally oriented to enhance these highly skilled individuals' capacities to integrate and innovate. By creating an institutional or societal environment that is open to hiring and promoting people from diverse ethnic and cultural backgrounds to work together, global talent (such as the Chinese students) will be encouraged to utilize their transnational capital and innovative capacity to make a greater contribution.

The findings of this study also suggest that Chinese students' economic and social integration are mutually supportive. Those Chinese students willing to reach out from their comfort zone to meet more local people and obtain more professional opportunities may also have better chances of finding job opportunities in the host society after graduation. It is also clear that those students with work experience in the local society also have opportunities to expand their social networks with the host natives. Overall, international students' economic and social integration is not only a crucial step in their entry into the local society, but also an attractive opportunity for hosting organizations and employers to build multicultural environments that can potentially enhance their productivity and build future sustainable development.

The present research will hopefully be useful for understanding the economic and social integration of Chinese students overseas, especially in the contexts of non-Anglophone countries. Despite its significance, it focuses only on Chinese students in the interviews conducted for this research. To further understand how to better retain international graduates, more studies on Chinese and other groups of international students in similar societal contexts should be conducted to corroborate the present findings. Further research is also needed to include the voices of employers, managerial staff of HEIs, and policymakers in order to assess their understanding and strategies for retaining highly qualified graduates. Finally, since the broad concept of integration for international students has the potential to include academic integration and cultural integration (cross-cultural learning), given the findings presented here, it would be useful to apply quantitative or mixed methods research to ascertain the extent to which these factors are primarily connected with students' integration.

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