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Innovation for Sustainable Business

Edited by

Iwona Zdonek and Adam R. Szromek

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About the Editors

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Preface to "Innovation for Sustainable Business"

Contemporary problems related to climate change and limited resources draw our attention towards changes in the field of sustainable activities. Moreover, the need for sustainable development creates opportunities for businesses by implementing innovations that are designed to provide a competitive advantage to those who apply more sustainable practices and who offer more sustainable products.

To promote the effectiveness of innovations for sustainable business, there is an urgent need to understand the conditions that influence the success or failure of their implementation, and to comprehend the complexities of their social, economic, and environmental dimensions.

We are pleased to invite you to read our book about innovation for sustainable business. It contains research, the conception, and case studies of ecological innovation and the green industry. A large part of the discussed issues was devoted to leadership.

We would like to thank all the authors of the following chapters of this book. We hope that their effort put into the exploration of the presented issues will contribute to a better understanding of the mechanisms inherent in innovation for sustainable business.

Iwona Zdonek and Adam R. Szromek

Editors

Article

The Drivers of Technological Eco-Innovation—Dynamic Capabilities and Leadership

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Abstract: In the paper, a theoretical framework that combines the multidimensional conceptualization of dynamic capabilities (sensing, seizing, and reconfiguring) with two leadership styles (transactional and transformational) and two types of eco-innovation (incremental and radical) was developed and empirically tested. The purpose of this study is to answer the key question: how different leadership styles influence the potential of dynamic capabilities to generate ecological changes. The research examining the theoretical framework was quantitative and was based on a deliberately selection of the sample, which included 54 of the most evo-innovative Polish companies. The results indicate that transformational leadership moderates the positive relationship between seizing capability and both incremental and radical technological eco-innovation, whereas transactional leadership moderates the positive relationship between reconfiguring capability and both types of analyzed changes. This paper contributes to the development of the literature by integrating three theoretical concepts, showing the importance of a given leadership style as a factor enhancing the potential of dynamic capabilities for the development of technological eco-innovation. Moreover, the study may be a contribution to a broader discussion on the specifics of eco-innovative activity and its behavioral conditions.

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1. Introduction

Modern companies have to deal with increasingly frequent changes taking place in their environment. These changes result from globalization [1], liberalization of trade, the growing intensity of competition in international markets [2], the accelerating pace of technological progress, and the associated shortened life cycle of many technologies [3]. These changes are accompanied by environmental problems related to the increase in population and industrial production and the depletion of nonrenewable resources [4]. The growing range of environmental restrictions, including high and unstable energy prices [5], restrictive environmental regulations [6,7], the limited possibility of using natural resources [8], as well as increasing environmental awareness of consumers [9,10] imply the necessity to include ecological issues in the activities undertaken by companies. After years of ignoring the ecological consequences of their activities, most entrepreneurs are aware of the need to create innovative technological solutions leading to balancing economic and environmental benefits. This is happening in many economies and is testified by the Polish Ministry of Climate's program entitled 'GreenEvo—Green Technology Accelerator' that is prepared for Polish entrepreneurs. The aim of the GreenEvo Program, financed by the Polish National Fund for Environmental Protection and Water Management, is to support the best innovative environmental technologies developed by Polish companies and assist in the promotion and international transfer of these solutions.

Considering eco-innovation in the development strategies implemented by companies requires undertaking academic research leading to the search for an answer to the question: how to conduct eco-innovation activities effectively? The paper refers to previous studies suggesting that efficient management of eco-innovation—embedded in the organizational

culture [11], organizational structure [12], strategic vision [13], and strategy development processes [14]—requires developing, integrating, and modifying the resources and competences held by companies. It, therefore, requires building dynamic capabilities. The logic of the dynamic capability concept [2,15] may explain why many companies that succeeded in the past (by generating environmentally friendly innovations) have faced deepening problems resulting from their inability to adapt to changes in their environment flexibly. Moreover, since the concept of dynamic capabilities is embedded in the processes of organizational learning and knowledge management (i.e., critical mechanisms of organizational change) [16,17], an attempt was made to extend it to the role and significance of leadership strategies implemented in companies.

The paper integrates various theoretical concepts, including the innovation theory, dynamic capabilities concept, and the transactional and transformational leadership theory. Then, the impact of different leadership styles on the potential of dynamic capabilities to generate technological eco-innovations in Polish companies was described and empirically tested. The research was carried out among 54 of the most innovative Polish companies that were winners of the GreenEvo Program (1st round of research) and companies selected by the Specialist Observatory in Technologies for Environmental Protection (2nd round of research).

Despite the growing number of scientific papers dealing with the importance of dynamic capabilities, many researchers [17–20] emphasize that this concept still requires empirical confirmation. Moreover, the current scientific achievements in this area are relatively limited. They consist of primarily theoretical research and, if supported by empirical research, mostly case studies (except for [3,11,12,21]). Third, conceptual and empirical works [22,23] explore the role of dynamic capabilities mainly for generating conventional innovations. What is more, the reference of the concept of dynamic capabilities to eco-innovative activities is a topic explored to a relatively limited extent. Some of the few examples are qualitative studies by Mousavi et al. [24] and studies described by Chen and Chang [25] and Huang and Li [26] who, however, capture dynamic capabilities as a unidimensional construct. Fourth, the literature review indicates a shortage of research that would include the issue of dynamic capabilities in the context of managing technological eco-innovation. Therefore, the results presented in the paper extend the knowledge on the mechanisms of developing such innovation among eco-leaders. Moreover, the scope of the research responds to the need, emphasized by researchers [27,28], to identify organization capabilities that are antecedents of generating and implementing eco-innovations. Finally, the inclusion of leadership styles in a multidimensional conceptualization of dynamic capabilities has—so far—not been included in any model, despite its importance emphasized by researchers [25,29] for eco-innovation.

This paper aims to fill described gap, both in terms of the theoretical and empirical layers. In summary, although categories such as ‘dynamic capabilities’, ‘eco-innovation’, ‘transactional leadership’ and ‘transformational leadership’ have been theoretically analyzed in various approaches and contexts, the study is the first to examine—to the author’s best knowledge—the moderating effect of leadership styles on the relationship between multidimensional view of dynamic capabilities and incremental and radical technological eco-innovations.

2. Literature Review and Hypothesis Development

The changes that shape the business are critical determinants of the development of sustainable innovations (eco-innovations, green innovations). Eco-innovation is defined in this paper as a new solution that leads to the avoidance or reduction of adverse environmental impacts [13,29–38]. Eco-innovation can be developed by companies or non-profit organizations [39], it can occur in different sectors [37], it can be marketed or not, and it can be technological or non-technological nature [30]. Eco-innovation may concern the development of new products—including eco-design and recycling of products as a particular form of their recovery [40], new technological processes—end-of-pipe technologies

or cleaner technologies [36], new organizational methods—environmental management systems [41] and new marketing solutions—i.e., eco-labels [4].

The paper analyses technological environmental innovations (TEIs) developed by Polish companies. Due to the specificity of the GreenEvo Program, which is part of the implementation of the National Strategy of Energy Security and Environment, the simple division of technologies into integrated and end-of-pipe technologies was abandoned. However, because interviewed companies were sometimes multiple winners of the GreenEvo Program, the TEIs were divided into incremental and radical (for a given company). Incremental (evolutionary) TEIs concern progressive modifications of technological solutions known to the company [42]. Radical (revolutionary) TEIs are rarer than incremental ones, more original and complex, more challenging, and more resistant to change [43,44]. Referring to the definition of Chen et al. [13] (p. 7789), incremental TEIs concern ‘environmental technology that reinforces, modifies, or extends current environmental knowledge’. Radical TEIs refer to ‘environmental technology that departs from current environmental knowledge’. As both incremental and radical TEIs require the development of resources (especially knowledge resources) and competences, they were included in the research model.

2.1. Determinants of Technological Eco-Innovation

The results of numerous studies indicate that generating and implementing eco-innovation brings significant financial benefits. It also contributes to the increase in non-financial efficiency, strengthening the company’s reputation, and building a green image. Research confirming this conclusion was carried out on various research samples, in different national contexts, and among companies of contrasting sizes, including Polish and Hungarian publicly traded companies [45], Slovenian companies [46], Italian manufacturing firms [40], green-oriented SMEs in New Zealand [47], and Taiwanese manufacturing companies [48] as well as ICT firms [26] and Chinese companies [38]. For the eco-innovative activity conducted by companies to have an efficiency dimension, it is necessary to have a specific resource and competence base. According to innovation theory, the resources required for conducting such activities include financial, human (knowledge, skills, and experience of organizational members), and physical resources (machines and equipment for laboratories and other research and development units) [49,50]. According to the resource-based view of the firm (RBV), resources should be valuable, rare, imperfectly imitable, and non-substitutable (Barney’s VRIN framework), as well as durable and not easily traded [51,52].

The importance of resources for TEIs has well-established theoretical and empirical foundations. Concerning financial resources, Segarra-Oña et al. [53] state that total expenditure on the acquisition of new technologies determines the eco-innovative orientation of firms. According to human resources, Horbach [33] argues that the improvement of knowledge capital (measured by the number of highly qualified employees) stimulates TEIs. Similarly, Triguero et al. [36] indicate that qualified managers and available technical knowledge obtained from external sources increase the implementation of these changes. Moreover, research conducted among Italian [54] and German [10] entrepreneurs indicates the critical importance of conducting R&D activity for generating TEIs.

The competence-based theory is an extension of RBV, according to which gaining a competitive advantage (thanks to eco-innovation) not only depends on the resources held by firms, but also on the developed competences [55]. Some researchers use the terms ‘competences’ and ‘capabilities’ interchangeably, defining them as bundles of skills necessary to organize resources [7], the ability to achieve something by using and coordinating a set of tangible and intangible resources [40], capabilities that result from multiple repeated actions [56] or the ability to arrange resources thanks to the use of organizational processes [5]. These processes are specific to a given company and can be developed due to complex interactions between resources [52].

Both resource-based view of the firm and competence-based theory have been criticized due to their relatively static nature. Even though the resources and competences may be a source of a firm's competitive advantage, Collis [57] states that, although they are valuable, they are not always the source of a permanent advantage and are certainly not its ultimate source. Moreover, other researchers [20,58] argue that such a perspective is inadequate to explain companies' competitive advantage in a dynamically changing environment. Following this argument, it can be assumed that resources and competences alone will not be enough to develop TEs; it will not be sufficient to maintain a relatively permanent competitive advantage. One also (or primarily) needs other capabilities (higher-order capabilities) to dynamically develop, integrate, and modify the resource and competence base. In other words, dynamic capabilities are needed.

2.2. *Dynamic Capabilities and Technological Eco-Innovation*

In a landmark paper, Teece et al. [15] (p. 516) defined dynamic capabilities as 'the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments'. Following this logic, some researchers consider them as organizational skills or capabilities [59,60]. Such an approach emphasizes that dynamic capabilities not only change the resource base but must also be embedded in it and in nature-repeatable. In contrast, Eisenhardt and Martin [61] define dynamic capabilities in terms of processes (as concrete and identifiable strategic and organizational processes), while Zollo and Winter [62] consider them in the context of organizational routines, directly referring to the evolutionary perspective of change described by Nelson and Winter [63]. Finally, new definitions of dynamic capabilities characterize them much more broadly, as the orientation [64] or potential [20] of an organization, i.e., an aggregated multidimensional construct consisting of interrelated components.

According to Teece et al. [15] and Teece [2], dynamic capabilities can be disaggregated into the firm's capacity: to sense and shape opportunities and threats (sensing capability); to seize opportunities (seizing capability), and to enhance, combine, protect, and reconfigure its resource base (reconfiguring capability).

Sensing capability requires constant searching and exploration—Teece [2] analyses it in terms of creative activity—technological, market, and regulatory changes. Such a strategy not only results in undertaking R&D activities and, consequently, in developing technological competences, but also in understanding hidden demand, structural evolution of markets, and future (foreseen) environmental regulations. The more information and knowledge firms accumulate, the greater their chances of being involved in creating and developing economically viable TEs and the lower the risk of carrying out such activities (both in terms of incremental and radical changes).

Seizing capability involves maintaining and strengthening technological competences and complementary resources and investing in selected TEs when the opportunity arises. The most important in this context is the time (overtaking competitors), place (specific consumer groups or market segments), and the level of risk (a derivative of the amount of necessary financial outlays) of strategic activities [2].

Finally, reconfiguring capability is crucial for a flexible and anticipatory response to changes occurring both in the companies and their environment [2]. One of the traps limiting TEs is the excessive attachment to the resource base, which is manifested by the limited scope of actions related to searching and exploration of changes. Another trap is the targeted development of technological competences conditioned by the held resources and problem-solving strategies. Such a strategy may result in companies not making the most potential opportunities, even if they recognize them early. Therefore, according to Teece's [2] logic, managers must overcome at least two limitations, i.e., cognitive limitations and limitations resulting from the excessive concentration on resources and competences, which—using the Leonard-Barton [65] terminology—may paradoxically lead to core rigidities inhibiting TEs.

The described conceptualization of dynamic capabilities (sensing, seizing, and reconfiguring) has well-established analytical foundations because researchers used it both in theoretical analyses [2,17] and in empirical research [11,12,58]. Therefore, it can be a foundation for understanding the mechanisms that determine incremental and radical TEIs. What is more, such an approach to dynamic capabilities is characterized by internal consistency and solves the ambiguity of this construct emphasized by some researchers [58,66] and facilitates its operationalization.

2.3. Leadership Style As a Driver of Technological Eco-Innovation

The critical importance of the leadership style for eco-innovation is emphasized in the literature [13,25,67,68]. Moreover, concerning the development of TEIs, researchers indicate that the success of such activities—especially given their high level of complexity—requires the support (commitment, motivation, and inspiration) of the CEO and, therefore, requires strong leadership [29,56]. Vaccaro et al. [69] argue that new solutions do not necessarily have to be developed by the CEO. Still, their role is crucial to creating an intra-organizational context conducive to experimenting and introducing new processes, innovative practices, or flexible organizational structures. In the most synthetic approach, leaders can stimulate TEIs by formulating a shared and ecological vision [29], implementing an effective incentive system [25], and building an innovative organizational culture [13].

However, considering the level of novelty and the specificity of TEIs, it may turn out that incremental change requires a different leadership style than radical innovation. Building on the work of Burns [70] and Bass [71], the study examines two leadership styles (transactional and transformational leadership) to consider how specific leadership behaviors enhance the potential of dynamic capabilities to generate TEIs. Moreover, because—concerning innovative activity—the transactional and transformational leadership theory has been empirically confirmed, it was included in the research model and associated with TEIs (Figure 1).

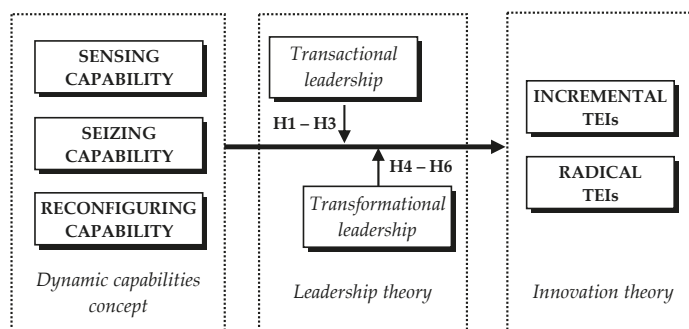


Figure 1. A Theoretical framework.

According to Bass's [71] model, the critical difference between transactional and transformational leader is the degree of commitment to conducting eco-innovation activities and the nature of their relationship with subordinates. Transactional leadership is based on building contractual relationships and creates a bond between the leader and subordinates based on the mutual benefits of such a relationship [69–72]. A transactional leader strengthens subordinates' involvement in the development of TEIs by awarding conditional rewards for the effective and timely implementation of tasks [69]. Besides, due to the complexity of TEIs, subordinates may be more likely to become involved in eco-innovation processes if it is associated with the possibility of obtaining tangible benefits (e.g., bonuses) offered by a transactional leader [72]. Moreover, the generation of TEIs often requires maintaining effective relationships with customers, suppliers, research and

scientific institutions, participation in professional associations, and adherence to best practices [21,68].

In this context, transactional leadership can effectively establish transparent and straightforward goals and policies and the expected outcomes of collaboration [69,72]. Moreover, in changing environments, companies need stability to identify opportunities or eliminate threats [16]. Due to the technological uncertainty accompanying the processes of generating TEIs, transactional leaders (who analyze the internal and external risks associated with undertaking such activities and identify discrepancies regarding agreed contracts) may favor its maximal reduction. Finally, transactional CEOs (rewarding proactive attitudes of subordinates and punishing them for reactive actions) can support the processes of strengthening the competences necessary to generate TEIs and reduce organizational inertia [73]. It can be assumed that task- and outcome-oriented transactional leaders will strengthen the potential of dynamic capabilities for the generation of TEIs. Based on this assumption, the following research hypotheses were developed:

Hypothesis 1 (H1). *Transactional leadership amplifies the positive relationship of sensing capability with (a) incremental TEIs and (b) radical TEIs.*

Hypothesis 2 (H2). *Transactional leadership amplifies the positive relationship of seizing capability with (a) incremental TEIs and (b) radical TEIs.*

Hypothesis 3 (H3). *Transactional leadership amplifies the positive relationship of reconfiguring capability with (a) incremental TEIs and (b) radical TEIs.*

Transformational leadership is not so much based on external motivation (exchange relationships) but internal one [69–71,74–76]. It is based on the assumption that the CEO considers the interests and the psychological needs of subordinates [76]. Thus, the emphasis is not on the consent or submission of employees but on their commitment, which strengthens their feeling that they go beyond self-interest to achieve the team's goals and/or the company [74]. The impact of transformational leadership on TEIs is manifested in four dimensions: inspirational motivation, individualized consideration, idealized influence, and intellectual stimulation. Thanks to their inspirational motivation, CEOs are a catalyst for TEIs, because they inspire and motivate subordinates expressing high expectations and giving meaning to their work [75]. Through individualized consideration, leaders treat each subordinate exceptionally, considering their individual needs and development paths [76]. Thanks to idealized influence, respected and trusted leaders are an authority for subordinates, making employees want to emulate them [64]. Finally, intellectual stimulation means that leaders encourage their subordinates to think creatively and innovatively [25,74] and mobilize them to seek environmentally safe—and not just economically effective—technological solutions. The climate of trust built by transformational CEOs [11] makes it possible to notice and understand the changing market, technical conditions, as well as potential threats essential to eco-innovative activity [26]. Likewise, supportive leaders facilitate the intensification of learning processes and the sharing of knowledge and experience [69]. Concerning the generation of TEIs, it is—therefore—necessary to adopt a broader perspective, taking into account not only the resources and competences, but also the learning processes, as well as the processes of coordination, integration, and reconfiguration of internal and external knowledge [15]. As argued by Wolter and Veloso [77], in this perspective, knowledge plays an equally important role as technology. In other words, transformational leaders—by supporting the orchestration processes of resources and competences [2], as well as (or primarily) strengthening the incentives for creative, productive, and innovative thinking [25,74] and mobilizing subordinates to question the status quo [76]—will enhance the potential of dynamic capabilities to generate TEIs. Based on this assumption, the following research hypotheses were developed:

Hypothesis 4 (H4). *Transformational leadership amplifies the positive relationship of sensing capability with (a) incremental TEIs and (b) radical TEIs.*

Hypothesis 5 (H5). *Transformational leadership amplifies the positive relationship of seizing capability with (a) incremental TEIs and (b) radical TEIs.*

Hypothesis 6 (H6). *Transformational leadership amplifies the positive relationship of reconfiguring capability with (a) incremental TEIs and (b) radical TEIs.*

3. Method—Sample, Data Collection, and Measures

To test the research hypotheses, a survey was conducted among the most innovative Polish companies generating TEIs. Non-random sample selection was used due to the requirement to meet restrictive conditions (companies participating in the study should be eco-leaders on the Polish market). The consequence of the adopted research methodology (and, at the same time, a significant limitation of the research) is the limited representativeness of the sample resulting from its arbitrary selection and its relatively small size. Both limitations significantly hinder statistical inference.

The survey was carried out from January to February 2019 and covered all GreenEvo winners ($n = 66$). As a result, the research sample includes companies involved in the TEIs development, which is confirmed by winning the competition and not only declarative assurances of the respondents. The survey was carried out using a Computer Assisted Telephone Interview. Since only 38 completed questionnaires were obtained (the response rate was 57.6%), it was decided to conduct the second round of survey among the most eco-innovative Silesian companies generating TEIs ($n = 32$). The companies were selected by the Specialist Observatory in Technologies for Environmental Protection (it was established in 2013 and was part of the ‘Network of Regional Specialist Observatories in the Entrepreneurial Discovery Process’ Project, implemented in 2017–2019 and co-financed by the European Regional Development Fund). The result of both rounds of surveys was obtaining 54 completely filled-in questionnaires. The descriptive characteristics of the research sample are presented in Table 1. The average organization size is 54 employees, and the average existence of an organization in the market is 19 years.

Table 1. Descriptive characteristics of the sample ($n = 54$)

Green Technologies	% of Sample ¹
Air protection	5.5
Renewable energy sources	37
Solutions supporting energy saving	28
Waste management	9
Water and sewage management	20
Biodiversity protection	9

¹ Percentages do not add up because respondents could select more than one answer.

The first stage of the research methodology was the development of a structured questionnaire using a 7-point Likert scale (from 1—‘I strongly disagree’ to 7—‘I strongly agree’ with a given statement). The original questionnaire was prepared in English and then translated into Polish. For this reason, the adequacy of the questions was assessed by analyzing them with five experts dealing with innovation and environmental changes. The received expert opinions helped improve several statements to ensure their clear and unambiguous understanding.

Several standard procedures were used in the study to increase response quality and to avoid the problem of common method bias. As Zhou et al. [3] (p. 738) notice ‘using a single survey respondent as the source for both the independent and dependent data may cause the possibility of common method bias’. Therefore, two independent respondents from each surveyed company were examined. Members of the management

team answered questions concerning dynamic capabilities and the TEIs, while lower-level managers' answers were the basis for measuring moderating variables. Both groups of respondents were guaranteed full confidentiality and anonymity of their answers. Finally, confirmatory factor analysis was performed, the internal consistency of the research tool was assessed, and the reliability and credibility of the measurement scales were checked. As shown by Kiefer et al. [78] such a procedure is associated with certain limitations, resulting from different respondents' perceptions, which is not unusual in the research on eco-innovation.

The survey questionnaire was divided into four modules. The first module included the measurement of multi-dimensional dynamic capabilities and referred to: (1) sensing capability, (2) seizing capability, and (3) reconfiguring capability. For the first two dimensions, the scales of Wilden et al. [12] were used. An essential premise for this choice was that the developed measuring scales were re-tested by Fainshmidt and Frazier [11]. The original scale developed by Wilden and Gudergan [21] was adapted for the measurement of reconfiguring capability. This scale is more detailed than the 2013 scale and allows capturing a broader spectrum of issues. The second module concerned the measure of technological eco-innovations developed by Polish companies. For both incremental and radical TEIs, the modification of Subramaniam and Youndt's [43] measurement scales was used [13]. The questionnaire included six statements (three for each dimension) regarding the development of TEIs, with varying degrees of novelty. In module three, respondents were asked to characterize their company's leadership style. Due to the necessity to limit the number of questions, the measurement of leadership with the original research tool (Multifactor Leadership Questionnaire) was abandoned. Instead, the questionnaire included six transformational leadership statements developed by Chen and Chang [25] and five transactional leadership statements, a modification of the measurement scale developed by Podsakoff et al. [79]. An essential premise of this choice was that Bass [71] originally distinguished only two aspects of transformational leadership, i.e., intellectual and emotional aspects, considering the dimension of charisma and inspirational motivation. Moreover, in subsequent studies, Bass showed the empirical lack of independence of both dimensions, emphasized by Waldman et al. [74]. Moreover, the meta-analysis by Lowe et al. [80] showed a lack of independence between individualized consideration and other transformational behaviors.

Finally, the statistical part of the questionnaire covered control variables, particularly the age and size of the company (measured by the number of employees) and the technological domain of their activity.

4. Analyses and Results

The Confirmatory Factor Analysis (CFA) was performed to assess the validity and reliability of measures. The obtained results showed that (concerning all variables) the degree of matching of the model to empirical data is satisfactory, which is confirmed by the theoretically proposed conceptual dimensions. Then, to assess convergent validity, the following parameters were calculated: Cronbach's Alpha (CA), composite reliability (CR), average variance extracted (AVE), and maximum shared variance (MSV). For all constructs, reliability parameters (CA and CR) reached values above the required thresholds of 0.7 [21]. The AVE surpassed the threshold of 0.5 for all scales [12]. Moreover, the condition relating to discriminant validity was met, stating that AVE should be higher than MSV. Taken together, these results show that the developed theoretical model largely overlaps with the empirical model (Table 2).

To test the research hypotheses, an analysis was performed based on hierarchical regression models, for which incremental and radical TEIs were considered as dependent variables. Following Aiken and West [81], the variables were centered to reduce the potential problem of multi-collinearity. Table 3 shows the results of hierarchical multiple regressions.

Table 2. Measurement scales and reliability.

Construct	Source	Mean	SD	CA	CR	AVE	MSV
Sensing capability	[12]	4.42	1.17	0.725	0.815	0.527	0.069
Seizing capability	[12]	5.69	0.48	0.825	0.854	0.595	0.069
Reconfiguring capability	[21]	3.45	0.97	0.863	0.878	0.510	0.048
Incremental TEIs	[13]	4.17	1.54	0.701	0.835	0.628	0.002
Radical TEIs	[13]	4.91	1.76	0.871	0.917	0.786	0.002
Transactional leadership ¹	[74]	4.81	1.18	0.853	0.843	0.520	0.028
Transformational leadership	[22]	4.96	0.76	0.961	0.950	0.760	0.028

¹ Regarding transactional leadership, it turned out that Cronbach's alpha calculated after removing the last item from the scale increased from 0.853 to 0.888. Such results indicate that this item negatively affects the consistency of the entire scale and constitute a premise for its removal from further statistical analyses.

Table 3. The results of the Hierarchical Regression Analysis.

Construct		Incremental TEIs			Radical TEIs		
		Model 1A	Model 1B	Model 1C	Model 2A	Model 2B	Model 2C
Control Variables	Organizational Age [^]	−0.001	−0.061	0.020	−0.034	−0.029	−0.003
	Organizational Size [^]	0.184	0.251	0.172	0.017	0.029	−0.015
	Technological domain 1	−0.090	−0.076	−0.084	−0.037	−0.079	−0.011
	Technological domain 2	−0.021	0.025	0.023	−0.139	−0.116	−0.115
Sensing Capability (SNC)		−0.010	1.426	0.379	0.323 **	−1.016	0.136 *
Transactional Leadership (TRC)			1.023 *			−0.338	
Transformational Leadership (TRF)				0.506			0.087
Interaction	SNC*TRC		−1.807			1.588	
Effects	SNC*TRF			−0.638			0.408 *
R ²		0.050	0.120	0.075	0.136	0.338	0.331
ΔR ²		−0.049	−0.014	−0.066	0.046	0.238	0.229
F		0.501	0.898	0.533	1.509	3.360	3.251
Control Variables	Organizational Age [^]	−0.020	−0.008	−0.016	−0.133	−0.139	−0.127
	Organizational Size [^]	0.149	0.150	0.150	−0.028	0.019	0.005
	Technological domain 1	−0.078	−0.072	−0.074	−0.017	−0.033	0.032
	Technological domain 2	0.009	0.010	0.014	−0.115	−0.083	−0.065
Seizing Capability (SZC)		0.299 **	1.549 **	1.321 **	0.426 **	1.174	0.834 **
Transactional Leadership (TRC)			2.238 *			1.773	
Transformational Leadership (TRF)				1.119 **			1.608
Interaction	SZC*TRC		−2.691*			−1.748	
Effects	SZC*TRF			−1.103 **			−1.584 **
R ²		0.135	0.218	0.273	0.209	0.295	0.365
ΔR ²		0.045	0.099	0.162	0.127	0.187	0.269
F		1.501	1.832	2.468	2.543	2.745	3.785
Control Variables	Organizational Age [^]	−0.110	−0.232	−0.214	−0.283	−0.218	−0.224
	Organizational Size [^]	0.260	0.362 **	0.338 **	0.145	0.125	0.108
	Technological domain 1	−0.068	−0.021	0.012	0.001	−0.046	0.017
	Technological domain 2	−0.016	−0.029	0.011	−0.151	−0.102	−0.119
Reconfiguring Capability (RCC)		0.304 **	2.326 **	2.140 **	0.493 ***	0.591 **	−0.378
Transactional Leadership (TRC)			1.139**			0.370	
Transformational Leadership (TRF)				1.488 **			−0.048
Interaction	RCC*TRC		−2.537 **			−0.294 **	
Effects	RCC*TRF			−2.765 *			0.954
R ²		0.133	0.290	0.258	0.254	0.374	0.290
ΔR ²		0.042	0.182	0.145	0.177	0.278	0.182
F		1.467	2.679	2.288	3.274	3.919	2.682

[^] Natural logarithm. Technological domain: 1—Water and sewage management. Technological domain 2—Biodiversity conservation. The estimation of the parameters for adjusting moderation models to empirical data is based on the use of the least squares' method. * $p < 0.1$ ** $p < 0.05$ *** $p < 0.001$.

An essential part of the analysis was the identification of direct relationships between dynamic capabilities and the generation of both incremental and radical TEIs. Model 2A indicates that sensing capability directly and significantly ($p < 0.05$) affects radical TEIs ($\beta = 0.323$). In regards to incremental TEIs, no significant relationship was identified ($p = 0.946$). Seizing capability directly and significantly affects the generation of both incremental and radical TEIs ($\beta = 0.299$; 0.426). Reconfiguring capability directly and significantly affects both types of eco-innovation (the values of the β coefficients are: 0.304 and 0.493 , respectively).

To test the research hypotheses, the remaining hierarchical regression models were assessed. An analysis of them shows that, for incremental TEIs, the coefficients of interaction between sensing capability and transactional and transformational leadership are statistically insignificant ($p > 0.1$). Similarly, concerning radical TEIs, the interaction factor between sensing capability and transactional leadership is insignificant (model 2B). In turn, the estimation of model 2C only allows for the assumption that there is a tendency for the moderating influence of transformational leadership on the analyzed dependence ($\beta = 0.408$, $p = 0.084$). Therefore, the obtained results do not justify the confirmation of H1 and H4, assuming that (transactional and transformational) leadership style amplifies the positive relationship of sensing capability with (a) incremental TEIs and (b) radical TEIs.

In contrast, the results presented in Table 3 show that the interaction coefficients between seizing capability and transformational leadership are significant in both model 1C and 2C ($p = 0.011$ and 0.016 , respectively). Such results confirm H5, which states that transformational leadership amplifies the positive relationship of seizing capability with (a) incremental TEIs and (b) radical TEIs. In turn, by narrowing the analysis to transactional leadership, the estimation of model 1B only allows assuming the tendency for the existence of a moderating influence of this leadership style on the relationship between seizing capability and incremental TEIs ($\beta = -2.691$, $p = 0.080$), which—as in the case of sensing capability—does not constitute a basis for concluding the nature of this relationship. Finally, the data included in Table 3 (model 2B) shows that the interaction coefficient between seizing capability and transactional leadership is statistically insignificant. Therefore, the obtained results do not justify the confirmation of H2, which states that transactional leadership amplifies the positive relationship of seizing capability with (a) incremental TEIs and (b) radical TEIs.

Regarding reconfiguring capability, the coefficients of interaction between this dimension and transactional leadership are statistically significant, both in model 1B and 2B ($p = 0.049$ and 0.027 , respectively). In other words, the obtained results confirm H3, assuming that transactional leadership amplifies the positive relationship of reconfiguring capability with (a) incremental TEIs and (b) radical TEIs. The analogous analysis carried out for transformational leadership (model 1C) only indicates the tendency to have a moderating influence of this leadership style on the relationship between reconfiguring capability and incremental TEIs ($\beta = -2.765$, $p = 0.057$). In turn, as shown by the estimation of model 2C, the interaction coefficient between reconfiguring capability and transformational leadership is statistically insignificant. Therefore, the obtained results do not justify the confirmation of H6, assuming that transformational leadership amplifies the positive relationship of reconfiguring capability with (a) incremental TEIs and (b) radical TEIs.

5. Discussion

The objective of the paper was to investigate how different leadership styles affect the potential of dynamic capabilities to generate technological environmental innovations in Polish companies. The results confirm (overwhelmingly) the importance of dynamic capabilities for both incremental and radical TEIs. Only concerning sensing capability and incremental TEIs, no statistically significant relationship was noted. Such results mean that companies with a strong ability to monitor the environment will better understand what the stakeholders expect and meet these needs by generating (according to the research—radical rather than incremental) TEIs. This conclusion can also be linked with the concept

of organizational learning [82] and with the research stream relating it to innovation [17]. Although both exploration and exploitation play an essential role in undertaking innovative activities, the main effect of exploitation is incremental innovation. The result of exploration is the development of radical solutions [83,84]. It can be assumed that radical TEIs require organizational procedures that support the search and detection of new external knowledge while using internal knowledge [85]. In turn—according to the obtained results—relying on internal knowledge may be enough to develop less original and less complex TEIs successfully. Moreover, the highest statistical significance was noted for the relationship between seizing and reconfiguring capability and radical TEIs. Therefore, the results show that investing in green research and development and increasing interdisciplinary cooperation in developing new environmental technologies are the critical conditions for creating original and complex TEIs.

5.1. Implications for Theory

A significant theoretical contribution of this paper is the confirmation—in the conditions of the Polish economy—of the usefulness of operationalization of individual variables. The reliability of the applied measurement scales indicates that the developed research model can be used in subsequent studies confirming the strength and direction of the analyzed relationships. Moreover, the results of the conducted research indicate the existence of several interesting theoretical implications relating to individual dimensions of dynamic capabilities.

5.1.1. Sensing Capability

The identified lack of statistically significant interactions between sensing capability and the leadership styles suggests that identifying new opportunities and eliminating threats (in conducting effective eco-innovation activities) may require changing the concept of leadership adopted in this paper. In other words, the described dimensions of leadership may not be theoretically appropriate for the context of dynamic search for opportunities to create TEIs. Secondly, even with the failure to build contractual or emotional relations between leaders and subordinates, they may undertake cooperation (in eco-innovation) with customers, suppliers, and R&D partners. It would not necessarily result from the proactive attitudes of employees (being a consequence, rather than a condition for undertaking cooperation), but from the desire to maintain a positive image of the company [41] or meet the expectations of key stakeholders [74]. Thirdly, the dimensions of transactional and transformational leadership can complement each other. This joint style of leadership is known as situational leadership [86] and has much in common with the recently studied enabling leadership [87]. What is more, leadership may be direct (close leadership) or indirect (distant leadership), in which the influence of leaders on subordinates occurs in a cascade through the decisions of middle and lower-level management [75]. In this approach, the transactional (or transformational) leadership style does not necessarily condition the same behavior at lower levels in the management hierarchy. Finally, it may turn out that other leadership characteristics affect the relationship between sensing capability and generating TEIs. Such a conclusion refers to Teece [2] and Fainshmidt and Frazier [11], who argue that the effectiveness of dynamic capabilities is an effect of the skills, knowledge, and experience of senior managers. Therefore, when interpreting the results, it is worth referring to the analysis of the impact of the management team's characteristics on undertaking innovative activities. Numerous studies (e.g., [88]) explain why the same environment is perceived by some managers as a source of opportunities, while for others, it is synonymous with danger. Such divergent managerial attitudes lead to the general conclusion that environment is usually interpreted by the CEO through mental 'filters', resulting from their age and level of education [89], managerial tenure [90], and professional experience [91].

5.1.2. Seizing Capability

The critical difference between a transactional and transformational leader is the nature of their relationship with subordinates. A transformational leader promotes employees' creativity, inspires them to think creatively, and mobilizes them to undertake research and experimental work [25,72]. Such activities (focused on the effective use of opportunities) result—as the research shows—in incremental and radical TEIs. These results partially support the arguments of Ambrosini et al. [18], according to which managerial perceptions of the need to change are crucial for developing dynamic capabilities. Moreover, the results obtained are consistent with the findings of Lopez-Cabrales et al. [92], who empirically proved that transformational CEOs' leadership style is positively related to seizing capabilities.

Thanks to inspirational motivation and individualized consideration, a transformational leader strengthens the personal involvement of subordinates in conducting environmental R&D activity and increases its effectiveness (by stimulating subordinates' sensitivity to specific ecological problems). Moreover, since generating TEIs is risky, a charismatic leader may facilitate the implementation of selected technological projects by formulating a clear vision integrated with the green strategy (common ecological goals, collective values, and desired organizational behavior [75]). Finally, through intellectual stimulation, a transformational leader strengthens the subordinates' sense of the economic importance of the opportunities and the environmental and social outcomes of the projects. This is especially important when undertaking experimental activities with results that are difficult to predict. Thus, the results complement the research conducted by Akkaya [93], indicating the critical role of transformational leadership in building dynamic capabilities by creating an organizational environment in which employees are encouraged, motivated, and inspired, as they are open to change and innovation.

Interpretation of the results is related to the specificity of activities leading to the use of opportunities and their time horizon. The logic of transactional and transformational leadership indicates that the former is based on the pursuit of personal (and assumed short-term) benefits by both the leader and their subordinates. In contrast, transformational leadership enables the organization's long-term goals to be achieved as a whole [74]. Since conducting environmental R&D is assumed to be long-term in nature, it can be expected that transformational (not transactional) leadership will strengthen the effectiveness of developing both incremental and radical TEIs.

5.1.3. Reconfiguring Capability

Despite the suggestion that transactional leadership may be less effective (in the context of enhancing the effectiveness of innovative activities) [72], the results indicate that it is transactional behavior that strengthens TEIs due to reconfiguring resources and competences. Such results do not support the findings of Lopez-Cabrales et al. [92], according to which not transactional but transformational leadership style is positively related to reconfiguration capability.

However, even a small change of processes, procedures and organizational structures is often costly and challenging (as it involves questioning conventional ways of thinking), deviating from proven (and routine) problem-solving methods [2]. Consequently, it can lead to increased anxiety within the organization. Therefore, the critical factor in this context is the scope and manner of influence of the CEO, who, thanks to a precise formulation of goals, directions, pace, and anticipated effects of such changes, can mitigate the negative attitudes of subordinates. The results obtained are consistent with discussion by Schoemaker et al. [94] on how dynamic capabilities, individual leadership skills, and strategic innovation are connected in a volatile, uncertain, complex, and ambiguous environment. Researchers indicate that crucial leader's characteristics that support reconfiguration are alignment and learning. Both refer to rather transactional actions such as ensuring challenging issues are surfaced to pinpoint misalignment, provide a compelling strategic vision,

encourage and exemplify transparent and rigorous debriefs, and stay agile course-correct quickly if off track.

Since strong resistance to change also results from psychological barriers, the most effective way to overcome it may be an equivalent exchange of benefits (which is the basis of transactional leadership). As emphasized by Kang et al. [72], in conditions of considerable uncertainty (referring to employees' concerns regarding their further employment), employees of new and innovative firms may be more interested in obtaining tangible benefits offered for the effective and timely implementation of their tasks.

Effective management of uncertainty (as well as overcoming the psychological barriers of subordinates) is much easier in innovative culture, i.e., an organizational culture, in which innovation is recognized as both a desired and a regular pattern of organizational changes. In such a way, the results obtained are consistent with the arguments of Vera and Crossan [95], who indicate that transactional leaders seek to strengthen not only strategy and structure but also the organization's culture.

Creating an innovative culture (including values, beliefs, and organizational symbols) is complex and requires the CEO to stimulate innovative attitudes of subordinates. Such motivating does not necessarily result from building emotional ties between the leader and subordinates but can (just as effectively) be based on the immediate satisfaction of their needs. Moreover, transactional leadership is not limited to rewarding (and punishing) the fulfillment of agreed contracts. It also considers the exchange of values (responsibility, honesty) between the leader and employees. Therefore, both transformational and transactional leadership may imply creating an organizational context supporting the involvement of subordinates in the implementation of a long-term green vision of organizational development.

5.2. Managerial Implications

The research results provide valuable insights to managers who wish to invest in both incremental and radical technological environmental innovations. While there is no universal recipe for success, this paper shows that building dynamic capabilities is positively related to TEIs. Thus, from a practical point of view, the sometimes elusive and abstract concept of dynamic capabilities may strengthen the effectiveness of companies' eco-innovative activities.

Moreover, research results suggest that the CEO's leadership style significantly determines the potential of dynamic capabilities to generate TEIs. In other words, not only the support and empathy of leaders but also establishing formal control and incentive mechanisms can help build an organizational climate that supports the use of dynamic capabilities in the TEIs development process. Building emotional relations between the leader and subordinates may increase eco-innovation activities by motivating and inspiring project members, investing in environmental R&D activities, and implementing individual development paths of employees involved in designing TEIs. On the other hand, building contractual relations between the leader and subordinates will be more critical in a periodic reconfiguration of the organizational structure. It can be done by creating new departments dealing with ecological solutions or appointing interdisciplinary teams dealing with the development of technologies and including specialists in environmental protection. These activities can help managers effectively use emerging opportunities and eliminate threats and configure (and reconfigure) their assets to flexibly respond to technological and competitive challenges of the future.

5.3. Limitations and Future Research

The limitations of the conducted research can be related to two categories concerning the model and research methodology. One of the most critical substantive limitations is popular in the literature view on dynamic capabilities by Teece [2]. In this way, the testing of hypotheses relating to other dimensions of dynamic capabilities was purposely abandoned. Moreover, while the direct and positive influence of these capabilities on

TEIs has been identified, developing them also carries costs that should be considered in future research. It would also be interesting to present dynamic capabilities not only through the prism of their multidimensionality but also the importance of each dimension perceived by the respondents. In such an approach, the conceptualization of dynamic capabilities should constitute a non-linear function of individual components. Moreover, their operationalization may require estimating different weights for each dimension [20]. Secondly, the paper is only limited to technological environmental innovations and does not consider other types of changes (e.g., organizational innovations). Thirdly, it views transactional and transformational leadership as two different leadership strategies. The suggested situational character of leadership indicates the limited effectiveness of a single leadership style for sensing capability. Finally, future research may consider other variables moderating the assumed relationships.

Concerning the research methodology, the most important objection is the limited representativeness of the sample and its relatively small size. Hence, the likely extension of the conducted research will be their replication in other contexts and on other (larger) populations. Secondly, because the research used subjective methods of measuring variables, it should complement them with objective indicators that could be verified a priori. Thirdly, the acquired data is cross-sectional. As Dangelico et al. [85] (p. 503) state: ‘although this approach is quite common among academic studies, scholars have raised some concerns about its validity that relate to causal inference’. Therefore, longitudinal studies should be a necessary extension of the performed analyses. An interesting direction for future research may also be to conduct qualitative research-based, for example, on in-depth interviews or case studies.

6. Conclusions

The research results indicate the necessity to consider different leadership styles in the analysis of the potential of dynamic capabilities for the generation of technological eco-innovations. The effectiveness of dynamic capabilities depends on specific social interactions, which is one of the most critical challenges for the CEO. On the other hand, the relationships between leaders and subordinates are the basis for implementing long-term development strategies, including the generation of TEIs. An important implication resulting from research is the confirmation of a given leadership style’s ambiguous influence on the relationship between dynamic capabilities and TEIs. In other words, the analysis results may contribute to a broader discussion on the specifics of an effective eco-innovative activity in which a given leadership style is characterized by the greatest organizational effectiveness.

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Article

The Idea of Corporate Social Responsibility in the Opinion of Future Managers—Comparative Research between Poland and Georgia

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Abstract: The article deals with the issue of corporate social responsibility (CSR) in the awareness of economics students as future managers responsible for the implementation of this idea in enterprises. Due to the fact that CSR is a source of many innovations today, the aim of the research was to learn about the awareness and opinions of students about CSR on such issues as: reasons for implementation, main activities, impact on profitability, and the need to explore and assess the usefulness of this knowledge. The research was conducted in 2019 among students from Poland and Georgia (as countries at various stages of advancement in the market economy). The results of the research were statistically analyzed in terms of obtaining answers to the hypotheses and research questions, checking the significance of differences in the answers due to nationality, and additionally, gender (chi-square test and test for two proportions). The primary contribution of this study is an exploration of the views of students on various issues of CSR and sustainability. The results showed that—according to students—ethical values, increased consumer awareness, and the desire to gain a competitive advantage are the most common reasons for the implementation of the CSR concept by companies. The vast majority of respondents indicated the need to enrich the knowledge of business ethics as an important aspect shaping the attitudes of employers and employees. The positive attitude of students regarding the impact of CSR on the company's profitability was confirmed, although the authors expected more unambiguous results. Differences were also distinguished between the responses of students from both countries on some issues, such as: opinions on the developing ethical sensitivity, the need for the credibility of the EU economic policy, ecology and relations with the local community, as well as relations with the closest stakeholders of companies. The results of the conducted research suggest the need for intense activity in the field of public awareness and the requirement of personnel training for the skilful implementation of CSR principles in enterprises.

Keywords: corporate social responsibility; the attitude of future managers towards CSR; ethical aspects of companies' operations

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1. Introduction

Innovation in business is part of a self-perpetuating virtuous circle. It leads to higher productivity and efficiency, which, in turn, drives innovation [1]. Although the sources of innovation are undoubtedly new technologies [2] and new social behaviors [3,4], many contemporary researchers argue that corporate social responsibility (CSR) becomes the flywheel of many innovations. CSR covers the methods by which an enterprise can obtain added value by dealing with the social and environmental aspects of its operations. Thus, it is a concept whereby enterprises voluntarily incorporate social and environmental interests in their market action strategies, as well as in their relationships with various stakeholder groups [5]. Conducting social dialogue at the local level is not only conducive

to increasing the competitiveness of enterprises at the global level but also—importantly—shaping the conditions for sustainable social and economic development [6]. According to the research [7], CSR as an innovation process is driven, on the one hand, by social and ecological values and, on the other hand, by economic value. Companies that want to develop and meet the expectations of stakeholders turn to the concept of CSR. They use social innovation to improve their supply chains and reach out to socially and environmentally conscious consumers and often work with social innovators to deliver business solutions to social needs [8]. According to the research [9], social innovation is seen as a key driver of the transition from ad hoc philanthropic programmes to genuine sustainable development strategies.

Since, in the future, economics students will especially create management personnel of various organizations, hence the state of their knowledge, as well as acceptance and willingness to use the principles of corporate social responsibility, are very important, as this will determine the actual transmission of this idea into the social and economic reality. That is why, at universities educating in the fields of economics and management, it is particularly important to explore issues related to corporate social responsibility. Realizing the importance of the problem, an attempt was made to diagnose the actual state of awareness of these students [6]. Until now, most of the research in this area has covered developed or developing countries. Comparative studies between the countries that are between this continuum are in the minority and usually involve closely neighboring countries [10,11]. Therefore, with this state in mind, we diagnosed a research gap that needs to be filled.

Analyzing the approach in the countries of the former Eastern bloc, Poland, as a rapidly developing country, and Georgia, as a country moving slower towards a market economy, were selected as representatives. This is confirmed by the ranking presented in the [12], created on the basis of GDP per capita, adjusted for purchasing power parity (PPP). Poland ranks 46th and Georgia 105th. This allows the assumption that both countries are at a different stage of building civic awareness [13,14], which is confirmed by the ranking [15], also the Global Innovation Index 2020 report [1], and this creates the main premise for the research undertaken in this article.

Bearing in mind the diagnosed research gap, the aim of this article has been divided into four parts. All of them concern the examination of the awareness and opinions of students on the following issues: (1) reasons for the implementation of the CSR idea by companies, (2) main measures characterizing the activities of companies in the field of CSR; (3) the impact of CSR on the profitability of companies; (4) the needs in the field of exploring and assessing the usefulness of knowledge on the ethical aspects of business operations.

To implement the first and second parts, we asked the following research questions:

Research Question 1: What is the awareness of economics students in terms of contemporary reasons for implementing the CSR idea by companies? Do nationality and gender influence attitudes in this regard?

Research Question 2: What, in the opinion of economics students, characterizes the activities of companies in the field of CSR? Are there any differences based on nationality or gender?

We were inspired to pose these questions by looking at the implementation of CSR in various countries from a historical perspective [16–19], showing that the origins of this concept were associated with charity activities of companies, and then with pro-employee and pro-ecological attitudes. Literature studies on the maturity of the implementation of CSR concepts in companies show that the implementation of this concept may have an incidental, tactical or strategic level [20] and largely depends on the state of the general economy and even specific industries. However, the activities of companies related to the concept of CSR always widely echo in the mass media, causing changes in the awareness of society (including consumers) regarding the importance of the CSR idea. Therefore, an

interesting question is how this awareness is shaped in Poland and Georgia among young people who associate their professional future with the business.

To implement the third and fourth parts, we asked the following research questions:

Research Question 3: How, in the opinion of young people, does the implementation of CSR principles affects the profitability of companies? Do nationality and gender influence this opinion?

Research Question 4: What attitudes are represented by young people in terms of the exploration and usefulness of knowledge about the ethical aspects of business? Do these attitudes differ according to nationality and gender?

We were inspired to pose such questions from the literature research, which shows that the idea of CSR is perceived as generating revenues, that not only cover the costs of its implementation but also allow to achieve a competitive advantage [21–27]. On the other hand, there are also studies in which the idea of CSR is perceived as a space for manipulation under the guise of altruistic concern, which makes the idea of CSR having a negative impact on financial results [28]. Therefore, it is puzzling which of these concepts is more convincing to the public.

The research questions posed by us indicate that the nature of our research is exploratory. In our research, we focus on learning about the views of students (from two countries that differ in terms of the development of the market economy) on various issues of CSR and sustainable development. The implementation of the set goals and answers to the research questions determined the organization of this article. The paper is organized as follows. Section 2 highlights hypotheses development in terms of: (1) reasons for implementing the CSR idea, (2) characteristic activities of companies implementing CSR, (3) attitudes regarding the impact of CSR on the profitability of companies, (4) attitudes towards the usefulness of knowledge in the field of CSR. Section 3 describes the methodology of the empirical research. Results are reported in Section 4. Discussion of findings and theoretical and practical implications are described in Section 5. Section 6 presents limitations and Section 7 conclusion.

2. Literature Review and Hypotheses Development

2.1. Reasons for Implementing the CSR Idea

An interesting look at the reasons for implementing the CSR concept in companies is the historical approach to the development of this concept, proposed in the paper [16]. Already in ancient Rome, charity work was visible in the form of creating asylum, houses for the poor and the old, hospitals and orphanages. In the Middle Ages, the activities of the Romans continued in municipal and religious institutions [17]. Some corporations joined charity work in the 16th and 17th centuries. In the 18th and 19th centuries, during the domination of the British Empire, the concept of Victorian philanthropy appeared. It focused on the working class and the creation of social programmes, examples of which could be seen in practice, both in Europe and in the United States of America [18,19]. The end of the 19th century and the beginning of the 20th century saw the popularization of donations to orphan shelters and the creation of model industrial communities, in order to improve the quality of life of employees in the form of building workers' housing estates [18]. In the 1920s and 1930s, business managers began to take responsibility for balancing profit maximization with creating and maintaining a balance with the demands of customers, workforce and the community [18]. Together with the development of the business during World War II and the 1940s, companies began to be perceived as socially responsible institutions, and these responsibilities were discussed more extensively. In the 1950s and 1960s, the belief arose that companies were responsible not only for their legal and economic obligations, but should be concerned with the welfare of the community and the education and happiness of their employees [16]. Moreover, in the 1970s, after numerous environmental disasters, such as the oil spill, the public was concerned about the rapid population growth, resource depletion and environmental pollution [29]. This

resulted in numerous social movements in the field of environmental protection, as well as human and labor rights. These movements continued in the 1980s, where, in addition to environmental issues, there were also protests against employment discrimination and consumer abuse. Moreover, there were protests against such activities of companies that threatened the health and safety of employees and worsened the quality of life in the city. The aggressive practices of international corporations were also publicized and criticized. Movements and social unrest led to the creation of social and environmental laws that imposed additional obligations on companies regarding environmental protection, product safety and labor rights [18].

It is not only the historical analysis of the CSR concept that gives an insight into the reasons why companies implement this idea. Interesting conclusions can also be drawn from the analysis of contemporary consumer and employee attitudes. Cone Communications/Ebiquity Global CSR research from 2015 [30] reveals that 91% of global consumers expect companies to be involved in solving social and environmental problems. Thus, the majority of global consumers (90%) would boycott the company if they found out about unethical business practices. Global consumers are also able to bear certain costs related to the CSR concept. Most of them (71%) declare that they would pay more for a socially or environmentally responsible product. 81% are able to consume less to conserve natural resources. 61% declare that they prefer to borrow or share goods rather than buy new ones. Moreover, 62% would prefer to work for a socially responsible company, even if it offered a lower salary than another socially unsuitable company. A total of 57% would accept a poorer quality product but more socially and environmentally responsible. A total of 61% of consumers use Social Media to engage in CSR. Additionally, research in Poland [6,13], and Georgia [31–33] has indicated an increase in social awareness of CSR as an important reason for the implementation of the CSR concept. Although research in Georgia [32] shows the perceived shortages by society in terms of access to information on CSR practices in Georgian companies. In Poland, some authors [13] directly refer to the fear of losing good reputation by companies as the reason for implementing CSR, thus referring to the theory of legality and its links with CSR. Additionally, the paper [34] shows that companies implementing CSR are an attractive workplace for employees, especially from the millennials generation. Thus, CSR is perceived as a way to achieve success in the modern world economy, one of the ways to build the company's image and a way to meet customer expectations [6].

The analysis of the historical approach to the development of the CSR concept and the observation of contemporary consumer attitudes, both global, as well as in Poland and Georgia, let us notice a constant increase in society's awareness of the responsibility of companies for their activities, not only in the context of law and economy. Therefore, we present a hypothesis corresponding to the first research question, in which we assume that:

Hypothesis 1 (H1). *Changes in awareness and increased consumer expectations, as well as building a positive image of the company thanks to CSR are, in the opinion of students, the most common reasons for the implementation of the CSR concept by companies.*

2.2. Characteristic Activities of Companies Implementing CSR

CSR research, conducted by scientists [20,35–37], and the historical view on the implementation of the CSR concept show, that we can now distinguish three distinct groups of CSR activities, resulting from the aforementioned historical approach. These are the areas of activity: (1) philanthropic, (2) pro-employee, (3) pro-ecological. Philanthropic activities mainly include: financial support for charity organizations, schools, clubs, associations, amusement and educational parks, fire brigades, IT centres, organizing internships for pupils and students. Pro-employee activities primarily include training for employees as part of encouraging career development and lifelong learning, supporting mothers' work through flexible working hours, promoting equal opportunities for women and people over 45 years, funding awards for academic achievement of employees' children, organiz-

ing employee trips. Pro-ecological activities include: implementation of environmental management systems, introduction of less energy-consuming technologies, closed production cycle, use of non-toxic, biodegradable products, recycling of local waste, recycling in cooperation with suppliers, use of recycled materials in production, use of ecological cleaning equipment and procedures, use of environmentally friendly materials (chemicals, intelligent coatings that are easy to clean), furnishing the company with heating panels, use of rainwater for washing, sponsoring environmental education programmes for children, partnership in environmental projects in the city and training employees in paying attention to ecological problems.

Some scientists subject these groups of CSR activities to a specific classification and form nomenclature for them. An example of this can be works [38,39], in which CSR activities are classified into: Corporate Operating Performance (COP) and Corporate Social Performance (CSP). COP activities primarily benefit the company's closest stakeholders, such as employees and suppliers. CSP activities are oriented towards further company stakeholders, such as local communities.

In order to organize CSR activities in Poland [20], has developed a CSR maturity model. This model makes it possible to identify incidental, tactical or strategic levels of involvement of Polish companies in CSR. The incidental level consists of activities of companies in the field of CSR defined as ad hoc, unplanned, random or non-existent. The tactical level consists of activities defined as inconsistent implementation of planned, repeated projects and instrumental motivation. The strategic level consists of activities, in which the CSR concept permeates every aspect of the organization and is integrated with the company's business strategy. Research [20] has shown that, in Poland, about half of the companies use CSR at the incidental level, about 30% at the tactical level and about 20% at the strategic level. Moreover, small and medium-sized enterprises currently show the lowest CSR maturity, which is in line with the trends prevailing also in the works of other researchers in Poland [13,37] and in the world [40–42]. Moreover, as in other countries, CSR maturity is industry-specific [40,42,43], but most industries in Poland do not have generally accepted CSR standards. The conclusion is that, although Poland has significantly improved its institutional CSR context over the last 20 years, the level of CSR practices in enterprises is still quite low. That is why CSR researchers in the Polish reality also focus on the issues of educating future managers in the field of business ethics, especially the issue of CSR [6]. In turn, Georgia lacks detailed information on what companies do in the field of CSR [32], which suggests the presence of CSR at an incidental level. What is more, research [44,45] indicates that Georgia obtained a low index in such areas as: gender egalitarianism, future orientation and performance orientation, which leads to the conclusion that the poor development of CSR in Georgia is conditioned by the cultural characteristics of the local society [44].

Despite the incidental level of CSR implementation in both Poland and Georgia, it should be emphasized that the undertaken activities in the field of CSR are accompanied by promotion. Publicizing corporate CSR initiatives has gained in importance and, according to [46], communication spending in this area are in third place in the budget positions of large corporations. Public relations tools [47], social media [48,49], websites, company reports, information on philanthropy [50], as well as corporate image and brand positioning strategies [51] are used to communicate CSR activities. Therefore, both environmental issues, as well as human and employee rights, have become a permanent fixture in the social consciousness. Therefore, we present a hypothesis corresponding to the second research question, in which we assume that:

Hypothesis 2 (H2). *In the opinion of students, focusing on ethical values in human resource management and on pro-ecological solutions are the most common characteristics of companies that have implemented CSR.*

2.3. Attitudes Regarding the Impact of CSR on the Profitability of Companies

CSR is considered a concept that, on the one hand, generates costs for companies, that could be borne by other institutions instead of CSR, and, on the other hand, leads to increased financial results, thanks to the competitive advantage achieved through CSR. Therefore, the question arises whether the revenues generated by CSR activity outweigh its costs. Many researchers have sought answers to this question [21–27]. For example, Hemingway and Maclagan [52] believe that CSR provides space and a cover for fraudulent activities of management, which imposes the negative nature of CSR. Similarly, [28,53,54] are sceptical about the concept of CSR, pointing to the possibility of some kind of manipulative and greenwashing practices under the guise of altruistic concern.

However, although some researchers point to the negative impact of CSR on financial results, due to manipulative practices in the field of CSR, there are also those, who perceive CSR as a source of competitive advantage for companies [55,56]. The main premise confirming the positive impact of CSR on the company's financial results is the stakeholder theory [25,26]. According to this theory, lasting relationships with stakeholders generate profit for the company, therefore managing these relationships is the basis for creating value for the company. The research [21] confirmed the validity of Freeman's theory. They consider CSR as a strategy creating legitimacy, reputation, and competitive advantages. The implementation of CSR creates satisfied key stakeholders, who ensure the effectiveness of the company's operations and reduce its costs. For example, satisfied employees provide a company with productive work and reduced employment and training costs. In turn, satisfied customers reward the company with repetitive purchasing decisions, providing it with income. Satisfied investors borrow capital at a lower rate, which lowers the cost of capital. Satisfied with ecological management, the company's community lowers advertising costs, while satisfied regular suppliers lower the costs of certification and quality. Moreover, research [46,57,58] has shown that the implementation of CSR causes the company's customers to identify with it and become branded diplomats. A similar result of the research on the company's reputation was obtained by [59–61]. The results of these studies are also confirmed by the report [30], according to which, if a company implements CSR, it can count on trust (90% of global consumers), loyalty (88%) and a positive image (93%).

Although literature studies indicate that the idea of CSR can be perceived as generating costs that reduce the profits of companies, scientists more and more often provide evidence that the implementation of the CSR concept also generates revenues that not only cover the costs of its implementation, but also allow to achieve a competitive advantage. Therefore, we present a hypothesis corresponding to the third research question, in which we assume that:

Hypothesis 3 (H3). *In the opinion of young people, the implementation of CSR principles in companies does not reduce the profitability of these companies.*

2.4. Attitudes towards the Use of Knowledge in the Field of CSR

Global emphasis on environmental, social and economic issues regulated by law, which is very often mentioned in publications concerning the study of CSR implementation, especially in Poland (cf. [6,20]) and the perspective that they should be incorporated into the processes functioning in companies, arouse in the society the need to educate its members in this area. The more so because, as mentioned in [14], incompetent CSR activities may be badly received by the society. Moreover, the more and more frequent presentation of the CSR concept as a way to achieve success in the contemporary world economy, building the company's image and meeting customer expectations increases the need for CSR activities, as it indicates a positive impact of CSR implementation on the financial results of companies. On the other hand, such works as [13,20], indicate a lack of strategy in activities related to CSR, which most probably result from the lack of knowledge on the subject. Therefore, we present a hypothesis corresponding to the fourth research question, in which we assume that:

Hypothesis 4 (H4). *Most students agree that knowledge of the ethical aspects of business activities is useful in their professional life.*

3. Materials and Methods

3.1. Sample and Data Collection

The research results were collected in 2019 via an electronic questionnaire. Data from Poland comes from the University of Economics in Katowice, where 482 students (307 women and 175 men) were surveyed. In Georgia, 118 students (61 women and 57 men) completed the questionnaire, from a total of four universities: Ilia Uni, Tbilisi State Uni, Technical University and Black Sea Uni. Due to the demographic differences between Poland and Georgia (the population of Georgia is much smaller than the population of Poland), the disproportion in the number of students from both countries was considered favourable—because it reflects the reality. The distribution of the number of respondents by age and gender is presented in the table below (Table 1).

Table 1. Structure of respondents.

Variable	Value	Poland	Georgia	Total
Age	Up to 20	59%	33%	54%
	21–24	38%	55%	41%
	Above 25	3%	12%	5%
Gender	Female	64%	52%	61%
	Male	36%	48%	39%

3.2. Measures

The questions and measuring scales of the questionnaire used for the research are presented in Table 2. Moreover, the questionnaire contained a record with questions about gender and age.

Table 2. The relationship of research questions and questions in the questionnaire.

Research Question	Question	Scaling the Answers
RQ1	Select the sentences that, in your opinion, reflect the idea of Corporate Social Responsibility the best.	Multiple choice nominal scale
	What, according to you, determined the creation and development of the idea of Corporate Social Responsibility?	Multiple choice nominal scale
	According to you, what are the main reasons for companies to implement the principles of Corporate Social Responsibility	Multiple choice nominal scale
RQ2	What internal (inside a company) activities, according to you, reflect the idea of Corporate Social Responsibility in everyday business practice?	Multiple choice nominal scale
	What external (outside a company) activities, according to you, reflect the idea of Corporate Social Responsibility in everyday business practice?	Multiple choice nominal scale
RQ3	Does the introduction of the principles of Corporate Social Responsibility, in your opinion, cause lower profitability of the company?	5-point Likert scale
RQ4	Do you think that knowledge about ethical aspects of management is useful in future professional life?	5-point Likert scale
	Do you see the need to constantly develop and enrich knowledge from business ethics as an important element shaping the attitude of employer and employee?	5-point Likert scale
	Do you think that the students of the University should deepen their knowledge concerning the ethical aspects of corporate activities?	5-point Likert scale

3.3. Data Analysis

The obtained answers were subjected to statistical analysis in terms of obtaining answers to the hypotheses and research questions posed. The results were discussed taking into account the nationality and gender of the respondents, looking for hidden relationships. For this purpose, the Pearson chi-square test of independence was performed for the Likert scale questions. In cases, where the expected number obtained was too small, the Fisher exact test was applied. In turn, for questions with a multiple choice nominal scale, differences between the studied populations were searched for using the test for two proportions—separately for each possible answer. The assumed level of significance was 0.05 [62,63]. The results of the analyses are presented in charts, in accordance with the recommendations of Knafik [64,65]. The test results for multiple choice scales are presented in the butterfly chart, also known as the tornado diagram [66]. The results for the single choice scales are presented on the diverging bar chart [67].

4. Results

4.1. Reasons for Implementing the CSR Idea

In order to verify the H1 hypothesis, the respondents were asked about the main reasons for implementing CSR principles by the companies. It should be noted that the respondents chose a maximum of three answers. The frequencies of answers for Poland and Georgia were calculated and the significance of the difference between the fractions was calculated. Figure 1 presents the results.

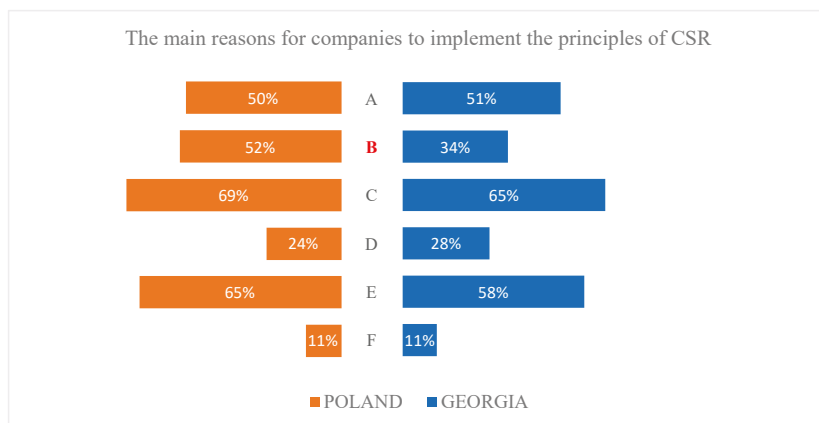


Figure 1. The main reasons for companies to implement the principles of CSR according to students of Poland and Georgia: A—Expectation from customers; B—Developing ethical sensitivity; C—Companies realise that a purely economic approach to business is not enough to be successful in today’s world; D—Companies are sensitive to social needs; E—Building the company’s image; F—I have no opinion, I don’t know. Note: Significant differences for the 0.05 significance level are marked in red.

The most frequently selected answer in Poland and Georgia was the statement that entrepreneurs realise that a purely economic approach in their activities is not enough to achieve success in today’s world (69% and 65%). The second most frequently chosen answer was building the company’s image (65% and 58%). In these respects, the respondents of both countries agreed. However, significantly more students from Poland than from Georgia marked the answer regarding developing ethical sensitivity ($p = 0.0005$). In Poland, no significant differences were found in the answers of men and women. The most common answers were C and E, although slightly more women chose the answer E first (68% and 63%), while men most often chose the answer C (72% and 64%). In Georgia, as in

Poland, there were no significant differences as to the substantive answers, but there were significantly more men who avoided answers (F: I have no opinion, I don't know; 18% and 5%; $p = 0.0286$).

Supplementary questions, verifying the H1 hypothesis, were the question about the reasons for the emergence and development of the CSR idea and the question about the understanding of CSR by the respondents. As before, these were multiple choice questions. The frequency of answers for Poland and Georgia and the significance of the difference between the fractions were calculated. Figure 2 presents the results.

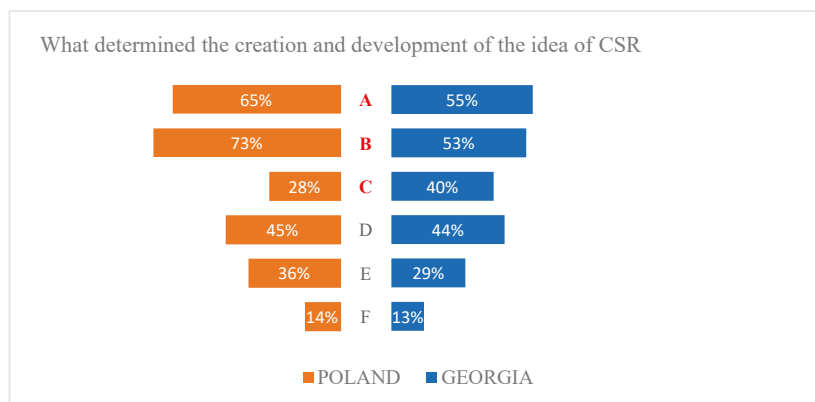


Figure 2. What determined the creation and development of the idea of CSR in opinions of students of Poland and Georgia? A—Increase in social expectations; B—Changes in consumer awareness; C—The need for credibility of the EU economic policy; D—The need to create long-term economic efficiency of enterprises; E—Media operation; F—Don't know. Note: Significant differences for the 0.05 significance level are marked in red.

The most common answer in Poland was the answer B regarding changes in consumer awareness as the reason for the idea of CSR (73%). Secondly, the respondents indicated answer A, which meant an increase in social expectations (65%). Additionally, these two responses were selected—equally—in Georgia (53% and 55%). Despite a similar tendency, the respondents of both countries marked the answers A ($p = 0.0382$), B ($p < 0.001$) and C ($p = 0.0106$) with significantly different intensities. Proportionally more Polish students indicated A and B, while answer C (the need for credibility of the EU economic policy) was chosen more often in Georgia (40% and 28%). The distribution of answers by nationality and gender (Table 3) shows that, in Poland, the most frequent answer of women was B (75%) and A (61%), and men—A (72%) and B (69%). Notably more men chose answer A ($p = 0.0142$). However, significantly more women marked E (media activity; 40%: 28%; $p = 0.0096$). Georgian students had a slightly more gender-specific answers. The most common answer of women was B (64%), then A (54%), while men: A (56%), and then B and D equally, pointing to, apart from changes in consumer awareness, also the need to create long-term economic efficiency of enterprises (40%). Significantly more women marked the answer B ($p = 0.0104$), while significantly more men were undecided (F: I don't know; 21%; $p = 0.0086$).

The results of the answers to the question regarding the understanding of CSR by the respondents are illustrated in Figure 3.

In both countries, the most frequent answers were F and E. The majority of respondents understand CSR as running a business in such a way, as to take into account ethical values, law, respect for employees, society and the natural environment (76% in Poland and 55% in Georgia), as well as providing services and products in a way, that does not degrade the natural and social environment (58% and 53%). Although the results presented in Figure 1

show a significant difference between Poland and Georgia for the answer F ($p < 0.001$), it is the dominant answer in both countries. Moreover, the respondents of both countries differed significantly in terms of the frequency of selecting the answers: A ($p = 0.0001$), C ($p = 0.0498$), D ($p = 0.0004$) and G ($p = 0.0354$). In Poland, no major gender differences were noticed in the answers (Table 4). Only that more women marked answer A ($p = 0.0486$), while more men marked G ($p = 0.0152$). However, in Georgia, significant differences, confirmed by the test, concerned the answers: B (38% women and 21% men; $p = 0.0478$) and I (64% women and 35% men; $p = 0.0017$).

Table 3. Significant gender differences: What determined the creation and development of the idea of CSR in opinion of students?

Responses	Poland			Georgia		
	Percentage		Significance of the Difference	Percentage		Significance of the Difference
	Female	Male	<i>p</i> -Value	Female	Male	<i>p</i> -Value
A: Increase in social expectations	60.91%	72.00%	0.0142	54.10%	56.14%	0.8237
B: Changes in consumer awareness	74.59%	69.14%	0.1970	63.93%	40.35%	0.0104
E: Media operation	39.74%	28.00%	0.0096	32.79%	24.56%	0.3242
F: Don't know	14.01%	14.29%	0.9325	4.92%	21.05%	0.0086

Note: Significant differences for the 0.05 significance level are marked in red.

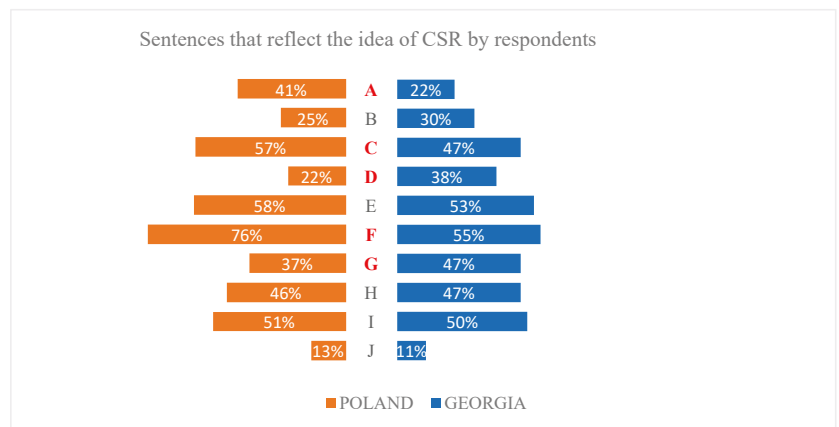


Figure 3. Sentences that reflect the idea of CSR by nationality: A—Achieving sustainable profit, while wisely shaping relations with all stakeholders; B—A management tool that lets you use the process of building a dialogue with stakeholders, in order to improve the company's development strategy; C—The philosophy of running a business based on building lasting, transparent relationships with all interested parties: incl. with employees, customers, suppliers, shareholders, competition and the local community; D—Building a strategy of competitive advantage in the market based on ensuring lasting value for both shareholders and other stakeholders; E—Providing services and products in a way, that does not degrade the natural and social environment; F—Running a business in such a way, as to take into account ethical values, law, respect for employees, society and the natural environment; G—Building and implementing a social commitment strategy that exceeds legal obligations, for the benefit of all citizens, in accordance with socially accepted ethical standards; H—Contributing to sustainable development by working with employees, as well as local and global communities, to improve the quality of life for all citizens; I—Voluntary consideration of social, ethical and environmental aspects in business activities; J—I have no opinion, I don't know. Note: Significant differences for the 0.05 significance level are marked in red.

Table 4. Significant gender differences: Sentences that reflect the idea of CSR.

Responses	Poland			Georgia		
	Percentage		Significance of the Difference <i>p</i> -Value	Percentage		Significance of the Difference <i>p</i> -Value
	Female	Male		Female	Male	
A: Achieving sustainable profit, while wisely shaping relations with all stakeholders	44.63%	35.43%	0.0486	19.67%	24.56%	0.5220
B: A management tool that lets you use the process of building a dialogue with stakeholders, in order to improve the company's development strategy	26.38%	21.71%	0.2529	37.70%	21.05%	0.0478
G: Building and implementing a social commitment strategy that exceeds legal obligations, for the benefit of all citizens, in accordance with socially accepted ethical standards	32.90%	44.00%	0.0152	44.26%	50.88%	0.4721
I: Voluntary consideration of social, ethical and environmental aspects in business activities	49.51%	53.14%	0.4431	63.93%	35.09%	0.0017

Note: Significant differences for the 0.05 significance level are marked in red.

Summarizing the presented results, it should be stated that the conducted research confirms the correctness of the H1 hypothesis. The most common reasons for implementing the idea in companies and for the development of CSR concepts in general are related, in the opinion of the respondents, to changes in awareness and increase in consumer expectations. Moreover, the respondents admit that, thanks to the implementation of the CSR concept, companies want to build their positive image.

4.2. Characteristic Activities of Companies Implementing CSR

In order to verify the H2 hypothesis, questions were asked about the internal and external activities characterizing the companies that implemented CSR. The respondents selected a maximum of 3 answers. The results are shown in figures (Figures 4 and 5)

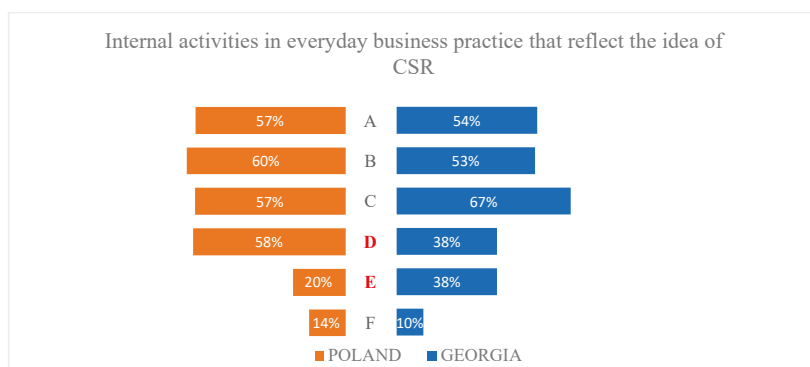


Figure 4. Internal activities in everyday business practice that reflect the idea of CSR, according to students in Poland and Georgia: A—Human Resources management; B—Ethical programmes for employees; C—Occupational Health and Safety; D—Environmental protection management; E—Principles of corporate governance; F—I don't know. Note: Significant differences for the 0.05 significance level are marked in red.



Figure 5. External activities in everyday business practice that reflect the idea of CSR, according to students in Poland and Georgia: A—Maintaining contact with the local community; B—Good relationships with business partners and suppliers; C—Good relations with customers; D—Respecting human rights in action; E—The use of pro-ecological solutions; F—I don’t know. Note: Significant differences for the 0.05 significance level are marked in red.

The most frequently selected answer regarding the company’s internal activities, which, in everyday economic practice, are the means of implementation of the CSR idea in Poland, was answer B (60%), while the next ones (D, A and B) had a very similar frequency (58% and 57%). Thus, Polish students equally marked such activities as: ethical programmes for employees, human resources management, occupational health and safety, as well as environmental protection management. Whereas, in Georgia, the most common answer was occupational health and safety (C: 67%). However, significant differences in the marked responses in both countries showed D and E (for p -value = 0.0002 and $p < 0.001$). In terms of daily activities in enterprises, which can be seen in CSR, Polish students marked environmental management (D) much more often than their Georgian colleagues. For the latter, however, CSR was more often associated with the principles of corporate governance (E). There were no significant differences between answers and gender in Poland. However, in Georgia, definitely more women selected answer A (62%: 44%; $p = 0.0448$).

Analyzing the differences between the countries, it can be seen that, in Poland, the issue of ecology is treated with more attention than in Georgia, where the issues of occupational health and safety, as well as the principles of corporate governance come to the fore. Therefore, we have here a reference to the company’s internal stakeholders and typical employee issues. The perception of CSR in Georgia in this aspect is also present in research [33], in which CSR focused on employee rights ensures a balance between work and private life and improves the health and safety of employees. The differences in terms of ecology may be explained by the observations contained in the research [44], which indicate that the low value of such an indicator as the future orientation, quite strongly related to the issue of ecology, leads to a weaker development of CSR in this area in Georgia, compared to other countries. In turn, the interest in ecological issues in Poland can be explained by research [68], which shows that the activities of Polish companies in the field of environmental protection are one of the most common and are oriented towards eco-education, optimization of resource use and elimination of waste, the use of new technologies and innovative solutions, in order to create new pro-ecological consumption patterns, formally strengthen all undertaken activities in the form of certification.

When asked what activities outside the company, in the everyday work, show the implementation of the CSR idea in both countries, the most common answer was D (67% and 69%). Respondents in both countries considered respect for human rights in action to be the most important aspect of external activities of enterprises. Significant differences were observed in answers A ($p = 0.0044$) and C ($p = 0.0129$). Definitely more Poles indicated

maintaining contact with the local community (A) as the external activities of companies under CSR, while more Georgians selected the option: good relations with customers (C). There were no significant gender differences in answers in Poland or Georgia.

Summarizing the results of the research, it can be said that, according to the opinions of students both in Poland and Georgia, orientation towards ethical values in the field of human resource management and pro-ecological solutions are the most common characteristics of companies that have implemented CSR. Thus, the obtained results confirm the second hypothesis. However, it is worth adding, when it comes to the verification of the second hypothesis, that the responses to the perception of external activities of companies implementing CSR indicate a great importance of respecting human rights in both analyzed countries. Therefore, this speaks in favour of enriching the original second hypothesis with this issue.

4.3. Attitudes Regarding the Impact of CSR on the Profitability of Companies

In order to examine the views of the respondents regarding the impact of CSR on the profitability of companies, they were asked whether the introduction of CSR principles reduces the company's profitability. They were asked to mark one of the five answers (according to the Likert scale). The results for both countries were gathered together in Figure 6. The chi-square test of independence confirmed the existence of dependence of the answers given on the respondents' country ($p < 0.001$).

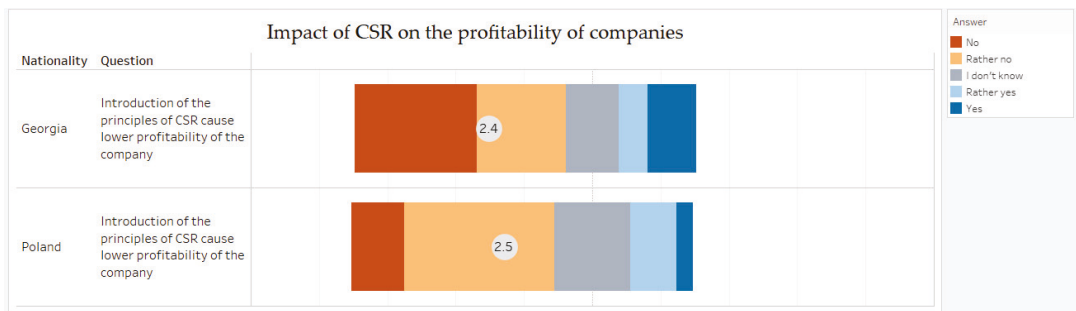


Figure 6. Whether the introduction of the principles of CSR cause lower profitability of the company according to Georgian and Polish students. 1—No; 2—Rather no; 3—I don't know; 4—Rather yes; 5—Yes. In the circle, the average value obtained from the given question is shown.

When analyzing Figure 6, it should be noted that the question presented in it was inverted, i.e., the answers "no" and "rather no" should be treated as positive, while the answers "yes" and "rather yes" as negative. Thus, despite the fact that the respondents from both countries indicated different individual answers, taking into account their attitude: positive to CSR (answers: "no" and "rather no"), together 62% (Georgia) and 59% (Poland), and negative (answers: "yes" and "rather yes"), together respectively: 23% and 19%, their answers showed no significant difference ($p > 0.05$). Most of the respondents do not believe that the introduction of CSR would reduce the company's profitability. In this way, it is possible to confirm the correctness of the third hypothesis, although the authors expected that the results would be more unambiguous in the direction of the answers "no" and "rather no".

The Pearson chi-square test of independence was carried out by examining the dependence of the answers given on the gender of the respondents in individual countries. The test result indicated the existence of this relationship, both among students in Georgia ($p = 0.0376$) and in Poland ($p = 0.007443$).

4.4. Attitudes towards the Usefulness of Knowledge in the Field of CSR

In order to answer the fourth research question, a diverging bar chart was created, presenting the answers to three questions of the questionnaire (Figure 7).

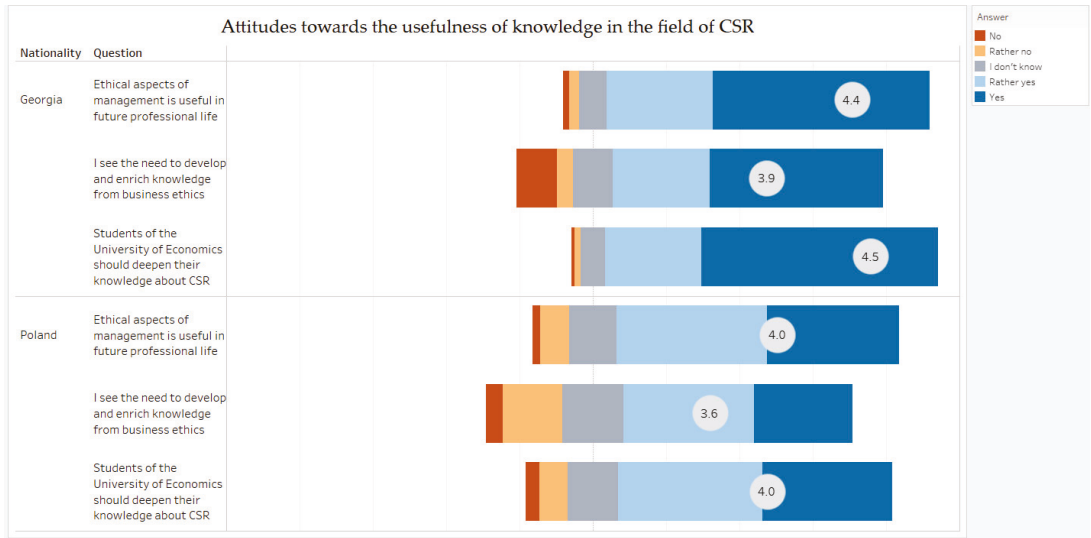


Figure 7. Attitudes towards the usefulness of knowledge in the field of CSR. 1—No; 2—Rather no; 3—I don't know; 4—Rather yes; 5—Yes. In the circle, the average value obtained from the given question is shown.

The first of them was aimed at examining the awareness of whether the knowledge about ethical aspects of management is useful in later professional life. The chi-square test of independence showed significant differences in the answers in both countries ($p = 0.0001588$). The vast majority of students confirmed the awareness of the usefulness of this knowledge in their later professional life. There were significantly more such answers in Georgia (88%), but also in Poland they were the majority (77%). In turn, by examining the dependence of the answers given on the gender of respondents in individual countries, its existence was confirmed among students in Georgia ($p = 0.03505$). Definitely more women gave an affirmative answer (96%), while among the undecided there were more men (14%). Additionally, among students in Poland, the existence of a dependence between the answer and gender was confirmed ($p = 0.007798$). Additionally, more women (albeit with a much smaller share than in Georgia) answered affirmatively (82%), while the answers “rather no” and “I don't know” were mostly given by men.

The second question concerned the need to constantly develop and enrich knowledge of economic ethics as an important element shaping the attitude of the employer and employee. Additionally here, the vast majority of respondents felt the need to enrich their knowledge of economic ethics as an important aspect shaping the attitudes of employers and employees. As many as 74% of Georgians answered “yes” or “rather yes”, while 63% of Poles chose the same answers. The chi-square test showed a relationship between the answers and nationality ($p < 0.001$). In Georgia, this relationship is also significant in terms of gender ($p < 0.001$), while in Poland it was not detected ($p = 0.5364$).

The third question concerned the opinion on the obligation to deepen knowledge about the ethical aspects of companies' activities. The independence test confirmed the existence of a dependence between the answers given and nationality ($p < 0.001$). Significantly more Georgians were in favour of the need to deepen their knowledge about the ethical aspects of business activities at universities (91%), however, the majority of Polish students also

noticed this need (75%). Still, there was no relationship between the answers and gender in both countries (Georgia: $p = 0.06449$, Poland: $p = 0.05395$).

5. Discussion of Findings

Our research has confirmed the first hypothesis assuming that ethical values, changes in consumer awareness, and the willingness of companies to gain a competitive advantage thanks to CSR are the most common reasons for the implementation of the CSR concept by companies. The differences between the answers of students from both countries related to several issues. The first is the opinion on the developing ethical sensitivity, which was indicated by Polish students significantly more often than in Georgia. In turn, the issue of the need for credibility of the EU economic policy was more important for Georgian students than for Polish students. Moreover, in Poland, men more often attached importance to the issue of increasing social expectations, while women to the role of the media in developing the idea of CSR. In the case of Georgia, men more often than women indicated the issue of changing consumer awareness. Comparing the obtained results with the research [30], a certain convergence can be seen. The dominant number of answers indicating that CSR is perceived as running a business in such a way, as to take into account ethical values, law, respect for employees, society, and the natural environment, both in Poland and Georgia, shows that CSR and the ethical values it entails are perceived as a way to solve social and environmental problems. Students in both surveyed countries present a similar perception of CSR as the global consumers indicated in the research [30]. In turn, the high number of answers related to ecological issues is consistent with the research obtained by [18] and shows that, in both countries, students perceive the issues of providing products and services in a way, that does not degrade the natural environment as very important. The high percentage of answers regarding building lasting relationships with all stakeholders of the company proves the convergence of the results with the research [21], showing the importance of the stakeholder theory for the issue of generating profit for enterprises. An interesting aspect of additional research would be to answer whether students' responses from countries at a different economic level coincide with the presented ones. Therefore, we are considering the possibility of conducting similar research in countries at a lower and higher level of development.

Our research has also confirmed the second hypothesis claiming that orientation towards ethical values in the field of human resource management and pro-ecological solutions are the most common characteristics of companies that have implemented CSR in the analyzed countries. In the analysis of differences between countries, the difference in terms of the greater importance of maintaining contacts with the local community in the perception of Polish students is noticeable, and in the case of Georgian students—greater importance of relations with customers. From these differences, it can be concluded that, for students from Georgia, relations with close stakeholders of companies are more important, while for Polish students—relations with further ones. The approach of Polish students can be explained by the research described in the paper [13], in which employees of Polish branches of international corporations have a similar attitude as students. Therefore, it points to the value system currently functioning in Polish society. By planning further research in this area, we can indicate that retrospective studies could also provide worthy of note results whether CSR's perception is changing in both countries. For example, will the results from both countries be more similar in 5–10 years? In our opinion, this should as well be the direction of future research.

We have also confirmed our third hypothesis assuming a positive attitude of students as regards the impact of CSR on the company's profitability. The results of the research in both countries are consistent with the conclusions about the positive impact of CSR on the profitability of the work of companies of such researchers as [21,26,57]. However, a puzzling factor is the large percentage of people in Poland, who are unable to determine the impact of CSR on profitability, which may be related to the research results presented in the paper [20], which emphasize the incidental nature of CSR activities of Polish companies.

Therefore, the lack of an unequivocal answer by 1/5 of the surveyed Polish students may indicate the awakening of awareness in this regard and the need to change the existing situation. This hypothesis, in turn, can be confirmed by similar studies carried out in a few years. Research at regular intervals could identify a trend in the development of consciousness.

Eventually, our research has also confirmed the fourth hypothesis assuming that in the opinion of students in both countries, knowledge of the ethical aspects of companies' activities is useful in professional life. The explanation of the need to enrich the knowledge and skills in the field of CSR, declared by Polish and Georgian students, can be based on research [13,14], which shows how difficult it is to build a civic community and how much knowledge is needed, so that CSR activities are not perceived as a smokescreen, greenwashing, or simply as incompetent, but in good faith [14]. Considering the results, the question arises what results would be obtained from the research on the introduction by academic teachers of economic courses of CSR content to their subjects. Is the perception of this need by academic teachers similar to the perception of students in both countries? What is the answer to the growing interest on the part of students in these issues? Should it be the adaptation of study programs, or what should be done in this matter?

Implication for Research and Practice

So far, research in the field of CSR has covered developed or developing countries. Comparative studies between the countries that are between this continuum were in the minority and usually involved closely neighboring countries. Thus, by researching countries such as Poland and Georgia, we filled the identified research gap. Our research has shown that countries slower-moving towards a market economy may have a slightly different perception of the concept of CSR. The concept of CSR can be perceived as activities directed towards closer than further stakeholders of enterprises.

Our research shows that students' awareness of CSR results from all the socially and environmentally responsible activities of companies on the market. Therefore, in the case of a megatrend related to the climate crisis and the need to adapt business to this crisis, it may happen that actions without a clear focus on ecology will be assessed as unsatisfactory. Therefore, companies should take various actions on a voluntary basis. They may concern, for example, the replacement of plastic packaging with more ecological ones, the implementation of the postulates of the zero waste concept or the circular economy.

The obtained results indicate that, although the concept of CSR is known and accepted by the societies of both countries, the complexity of issues related to its implementation in companies suggests the need to increase educational activities and educate personnel in skilfully implementing CSR principles in enterprises. It will be possible, inter alia, thanks to the expansion of the educational offer in this field at economic universities. The need to learn more about the ethical aspects of running a business reported by students in our research indicates that academic curricula should perhaps be directed to the more practical aspects of CSR. The implementation of project forms of teaching can bring satisfactory results, especially in combination with providing students with access to real problems faced by companies that want to be socially responsible. Such forms of teaching might be very well perceived by students.

6. Limitation

Although our research has shown that countries slower-moving towards a market economy may have a slightly different perception of the concept of CSR, we realize that comparative studies conducted in only two countries are insufficient to make such conclusions. Thus, we do not generalize our findings but we consider them only as a hypothesis that needs to be verified. Bearing in mind the exploratory nature of our research, we used a simple form of a questionnaire. Investigating with a more sophisticated form of the questionnaire would allow finding a broader context for the issues we are researching.

7. Conclusions

The article poses four research questions and verifies four hypotheses. The research was conducted in the context of differences related to nationality and gender. First of all, we were looking for an answer to the question of what the students' awareness is of the contemporary reasons for implementing the idea of CSR by companies. The conducted research allowed for the positive verification of the first hypothesis and, therefore, both in Poland and in Georgia, ethical values, changes in consumer awareness and the willingness of companies to gain a competitive advantage thanks to CSR are the most common reasons for the implementation of the CSR concept by companies. Secondly, we were looking for an answer to the question about the characteristic activities of companies in the field of CSR. The obtained results, especially those in terms of the perception of internal activities of companies implementing CSR, confirm the second hypothesis. Therefore, both in Poland and in Georgia, orientation towards ethical values in the field of human resource management and pro-ecological solutions are the most common characteristics of companies that have implemented CSR. However, it is worth adding, when it comes to the verification of the second hypothesis, that the responses to the perception of external activities of companies implementing CSR indicate a great importance of respecting human rights in both analyzed countries. Therefore, the verified second hypothesis should also be supplemented with this issue. In Poland, the issue of ecology and relations with the local community (and, therefore, further stakeholders of companies) is treated with more attention than in Georgia, where relations with the closest stakeholders of companies, i.e., employees and customers, come to the fore. Therefore, referring to the history of the development of the CSR concept, it can be seen that Georgia is at a slightly earlier stage of implementing this concept. Thirdly, we looked for an answer to the question of whether, in the opinion of the respondents, the implementation of CSR principles affects the profitability of companies. The obtained results indicate that it is possible to confirm the correctness of the third hypothesis, although the authors expected that the results would more clearly indicate the positive attitude of students as regards the impact of CSR on the company's profitability. The large percentage of the answers "I don't know" in Poland shows, according to the authors, the awareness of young people of the incidental nature of CSR activities, which suggests the need for intensified actions, not only to awaken public awareness, but to educate personnel, who can professionally implement CSR principles in the activities of companies. This conclusion is also confirmed by the results of research related to the last research question, i.e., related to the attitude that students present towards the exploration and usefulness of knowledge about the ethical aspects of business. The fourth hypothesis was confirmed and, therefore, according to the students, knowledge of the ethical aspects of companies' activities is useful in professional life.

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Article

The Green Side of Industry: The Drivers and the Impacts of ECO-Innovations in Brazil [†]

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Abstract: This study aimed to provide an overview of eco-innovations in the Brazilian industry. To address this issue, we analyzed specific data of eco-innovative companies. In addition, we applied the cluster heatmap technique, which allowed us to analyze the different drivers and impacts of eco-innovations in different sectors. According to the results, companies that stated that innovation made it possible to reduce their environmental impact represent a third of all innovators. Moreover, they are companies that have shown greater effort to innovate and greater susceptibility to the benefits and obstacles of innovation. Furthermore, the eco-innovation strategy is mainly driven by market factors, such as reputation and codes of good practice. The impacts are mainly associated with the use of more widespread and less complex technologies, such as recycling. In addition to these results, the study considers some alternatives to guide the innovation policy, especially related to eco-innovations in semi-peripheral countries.

Keywords: sustainability; green technologies; environmental innovation; industry; Brazil

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1. Introduction

The climate change scenario requires the application of a set of actions capable of tackling ecological, social, and economic problems. Harmonizing the economic, social, and environmental dimensions is at the core of the 2030 Agenda and the Sustainable Development Goals (SDGs).

The perspective that will allow the development of a sustainable technological model is mainly connected with two SDGs. The first, SDG 7 (affordable and clean energy), aims to ensure universal access to affordable, reliable, and modern energy services. Therefore, its purposes include: substantially increasing the share of renewable energy in the global energy mix; improving international cooperation to facilitate access to clean energy research and technology; and widening infrastructure and upgrading technology for supplying modern and sustainable energy services for all nations, especially in developing countries. The second, SDG 9 (industry, innovation, and infrastructure), aims to build resilient infrastructures, to promote inclusive and sustainable industrialization and to encourage innovations. Its included targets aim to: modernize infrastructures and to retrofit industries for strengthening sustainability, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial process; intensify scientific research, for improving the technological capabilities of industrial sectors; and encouraging innovation and increasing the number of workers and R&D resources (public and private), particularly in developing countries [1].

The preview targets in two SDGs are interconnected to the purposes of eco-innovations (EIs). The EIs follow practically the same features as general innovations—products, processes, and organizational techniques, which can be new to a market or company—but with the differential of reducing the environmental risks throughout its life cycle [2–4].

In discussions about technological changes, there are high expectations regarding the potential of green technologies [5–7] and the competitive advantages of EIs [8]. Investment targeting renewable energies, biotechnologies, and more technically and ecologically efficient products and processes is key to a new technological model [9–11]. In this respect, it is worthwhile to note that the principal economic policies today are closely tied to sustainable development, such as the European Green Deal in the European Union or the Green New Deal in the United States. In line with this paradigm shift in technology, development opportunities also arise for developing countries, specifically, in Latin America [12,13].

At the same time, there are challenges, especially for developing countries [14]. In the case of Brazil, the transition to a green economy and the encouragement of EIs has outlines that are well delineated to that of a developing country, requiring, above all, technological, financial, and institutional efforts. The ideal path presupposes that the country can promote structural change that increases productivity in a socially inclusive [15] and environmentally sustainable manner. However, in fact, this nation has provided a dual response to this situation in terms of government and public policy in innovation [16]. On the one hand, Brazilian innovation systems have some strengths built on the existence of all the components of a significant innovation system, for example, educational, research and regulation subsystems are important for our purposes here, the strategic natural resources, such as land, mineral and water supplies as well as biodiversity from land and maritime biomes. On the other hand, there are key system weaknesses, such as the frequent negative macroeconomic interventions in innovative productive activities and, perhaps the most critical, the absence of a consistent long-term vision or agenda, i.e., fragmentation and discontinuity in public policies and institutional configurations, that give direction and coherence to scientific research and public and private innovation efforts.

In this context, an important question is how developing countries, such as Brazil, have responded to the transition to a more sustainable development model. To illuminate this issue, the analysis combined elements of innovation, production and environmental protection from a sectorial perspective. The study examined specific EI data—drivers and effects—in Brazilian companies, considering two delimitations. The first concerns the identification of the group of eco-innovative companies, through the application of a specific selection criterion, directing the analysis to innovative companies that observed an environmental benefit from their generated innovation. The second delimitation relates to the sectorial profile, namely, the extractive and manufacturing sectors. The database is from the latest edition of Pintec (Pesquisa de Inovação), 2015–2017, which included specific issues about EIs for the first time.

Thus, the objective of this paper was to provide an overview of eco-innovations in Brazilian industry. Therefore, a comparative profile of two groups of companies (eco-innovators and innovators) was elaborated and, in the case of eco-innovators, the drivers and impacts of eco-innovations were analyzed. We believe that analyzing eco-innovative companies, especially in developing countries, is extremely relevant for challenges of the 2030 Agenda. The panorama of EIs in Brazilian extractive and manufacturing sectors indicated that the eco-innovative companies represent just over a third of the innovators. In general, these companies show a greater effort to innovate when compared to other innovators [17,18]. Associated with this greater commitment, eco-innovators demonstrate a greater perception of the benefits generated by innovation. Likewise, they also exhibit greater sensitivity to its obstacles. The analysis of drivers and impacts allowed us to enrich this profile, highlighting some central elements of environmental innovations, such as the fact that EIs in the Brazilian extractive and manufacturing activities are mainly induced by market factors, and that environmental regulations are not part of the most relevant determinants. Moreover, the most recurrent effects are related to the use of more widespread and less complex technologies, such as the recycling of materials, waste, and wastewater [19].

The article is structured as follows: Section 2 is dedicated to the theme of EI, with an emphasis on drivers and the effects that environmental innovation potentially generates.

Section 3 describes the methodology, in particular, the selection criteria, of the companies and the elaboration of the graphic elements of analysis. Section 4 focuses on results, with special attention to information from Pintec sustainability and the EI set. Section 5 discusses the main findings. Finally, Section 6 concludes by indicating possibilities to guide innovation policy, especially regarding eco-innovations in semi-peripheral countries.

2. Literature Review

For a long time, environmental protection actions were seen as an impediment to the economy, reinforcing the existence of a permanent trade-off between these two dimensions. Although the attachment to this idea is still manifested, technological advances and institutional conduct strategies (government, companies, civil society, NGOs, etc.) already allow us to make viable alternative and sustainable models of production and consumption for which EIs and green technologies are crucial.

In this direction, the proposition of Porter and Line [20] was a precursor in demonstrating that pollution was equivalent to inefficiency. When analyzing some sectors that were strongly influenced by environmental regulations, they found that the adoption of innovations and other factors that promote competitiveness allowed companies to reduce costs with environmental actions. Among other aspects, environmental standards were able to indicate inefficiencies, encouraging new solutions; sensitize companies about their production processes; reduce uncertainty about investments for environmental improvement; and pressure companies to eco-innovate [20].

Technological innovation policies play a primary role for the purposes of sustainable development. Therefore, the substitution of unsustainable production methods and consumption patterns by innovations capable of mitigating impacts on the environment is part of a broader context of technological evolution [21]. Thus, it is especially important that innovation and sustainability are developed together, as the needs foreseen in the meaning of sustainable development are dynamic and, consequently, susceptible to changes in the current context [22].

The concept of EI adopted in this analysis is from the report *Measuring ECO-innovation*: “[...] the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives.” [2] (p. 7).

Thus, a company can become an eco-innovator when it applies environmental technology, e.g., by developing equipment or processes that use inputs in a sustainable and efficient manner and/or reduces the effects of production on the most varied natural ecosystems. The manufacture of “green” products, the shared use of goods and the creation of environmental innovation systems, combining production and consumption to reduce impacts on the environment—such as organic products and renewable energies—are other examples. Another strategy is to adopt managerial or organizational methods, such as environmental management and certification systems, and prevention and cooperation programs, with other entities aimed at reducing the environmental impact [2,4].

A particular characteristic of EIs is the presence of the problem of double externality. As with in innovations in general, there are market failures due to knowledge externalities; in EIs, there are also failures attributed to the environmental benefits generated, which increases the risk, discouraging the development of EIs [23,24]. Therefore, the application of environmental standards is essential to encourage EIs and to reduce the double externality for companies that develop innovations.

As highlighted, our focus in this study was the impacts and drivers of EIs. In relation to the effects, or impacts, of EIs, these are commonly associated with the notion of performance. Studies that analyze impacts emphasize both the results directly perceived in the environment—for instance, the replacement or more efficient use of energy and inputs, and

the reduction in contamination in soil, water, and air—and others of economic character, such as financial performance, competitiveness, and market value [25–28].

In addition, there is a classification that links the impacts of EIs to a kind of innovation. The effects of product EIs refer to improving the recycling of products after use; reducing energy consumption; and reducing emissions in water, soil, and noise. The impact of process EIs corresponds, in addition to the last two products' effects, to the reduction in materials per product unit; the decrease in energy use per product unit; the decrease in CO₂ and other pollutants in the air; recycling waste, water or materials; and replacing hazardous substances [8].

The factors that induce companies to seek solutions to reduce their environmental impact, either reactively or proactively [25,27], are among the most analyzed aspects in the literature [26,29].

To analyze the drivers of EIs, we adopted the theory of environmental innovation [17], which includes both general aspects of innovations and particular aspects of EIs. Just as Horbach [8,17] and Triguero et al. [30], we categorized the determinants into three main groups: supply-side factors, demand-side factors, and institutional and political influences of an environmental characteristic. While the first two groups are widely known in innovation studies, the third—environmental and policy influences—is specific to EIs [31,32].

Hence, based on the factors listed by the theory of environmental innovation [17], it was possible to associate in each group of determinants the drivers present in the special survey by Pintec (Table 1). Pintec listed nine specific factors that contributed to the company's eco-innovation decision.

Table 1. Determinants, nature of factors and inducers (Pintec) of environmental innovation.

Determinants	Nature of Factors	Inducers (Pintec)
Supply-side	Technology push Cost-savings	Government support High costs of energy, water, raw materials
Demand-side	Market pull	Voluntary actions Codes of good practice Market demand Reputation
Environmental and policy influences	Regulatory pull/push	Existing environmental standards Future environmental standards Public contract requirements

Source: Adapted from [8,17,30].

The supply side factors are those related to the technological capabilities available for the company to innovate [33]. As with innovations in general, the factors correspond to the company's technological and organizational capabilities [17,34]; the cooperative relations with suppliers, research institutes, agencies and universities [8,30,32,35,36]; the access to external information and knowledge [35,36]; and the access to subsidies and fiscal incentives [31]. Other factors related to the supply-side are energy and material cost-saving strategies [8,34,37].

In turn, demand-side elements highlight market forces as the main determinants of technical change and, therefore, of stimulating (eco)innovations [33]. Among the main factors, the market pull is the possibility of expanding market share [8,17,38]; the increased market demand for green products and eco-label adoption strategies [15,39,40]; and the social awareness actions of the need for clean production [26,38], such as voluntary actions or codes of good practice, mainly resulting from pressure from stakeholders and consumers [22,31,34]. In particular, the institutional pressure can trigger a technological change within the company and therefore redirect R&D efforts for projects related to the environment [41].

A specificity of the determinants related to environmental regulation is the notion of regulatory pull/push. The empirical verification shows that the regulatory structure and environmental policy generates significant effects on EIs. This is due to the fact that these, unlike those in the fields of microelectronics or telecommunications, are not self-applicable; that is, the factors of market pull and technology push are not strong enough to develop them. Therefore, EIs need specific regulatory support, capable of inducing (pull) and boosting them (push) [23]. In this group of drivers, there are environmental standards and regulations, including the expectation of stricter future standards; environmental taxes and duties; and indirect instruments, such as the imposition of requirements for public procurement. It is worth mentioning that the effects of environmental regulation of the development of EIs is among the main topics in the analysis of environmental innovation drivers [8,18,20,22,31,37,42].

3. Material and Methods

The research was structured in two stages (Figure 1). The first focused on the selection criteria for eco-innovative companies. A significant part of quantitative studies on innovation uses surveys, such as the Community Innovation Survey (European Union) or Business R&D and Innovation Survey (United States). In particular, the surveys are a relevant base of information about drivers of EIs [8,15,43]. In the case of Brazil, the most well-known base of innovation statistics is Pintec, from the Instituto Brasileiro de Geografia e Estatística (IBGE). Pintec is a sample survey, conducted over a three-year period, and applied to companies with more than 10 employees belonging to the sectors of industry, electricity and gas, and selected services [44]. In addition to contemplating the unprecedented information from the last Pintec about the drivers and impacts of EIs, the objective of this study was to specifically analyze eco-innovative companies. To this end, questions related to the theme of innovation and the environment were identified in the general questions block. The question chosen to differentiate companies between innovators and eco-innovators was N° 105, which asks about the effects of product and process innovations in reducing the impacts on the environment [44,45]. In this question, companies must manifest this effect, indicating one of four levels of importance: high, medium, low, and not relevant. The issue, as proposed in some studies [8,17,18,46,47], is a measure of environmental performance and, therefore, a proxy to differentiate eco-innovative companies from others.

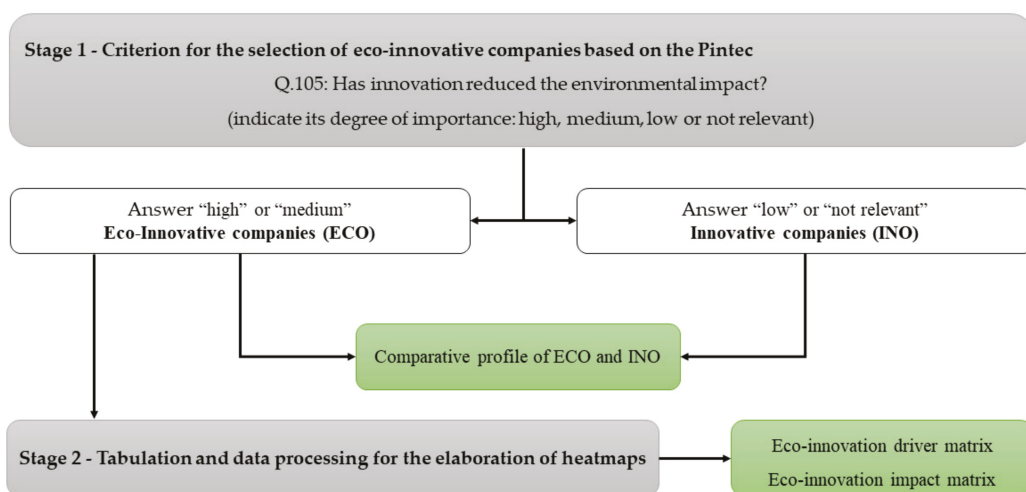


Figure 1. Design of the stages of the study methodology.

Nevertheless, it is pertinent to make two brief considerations about the data. However, the survey also probes about the reduction in the consumption of other inputs (energy, water, and materials); this effect results much more often from cost saving, rather than from an initial guideline of environmental conduct [2,47]. Another point is the bias present in approaches on the environmental impact. The responses of companies may be subject to corporate rhetoric and, consequently, may be overestimated [48].

Based on the definition of the criteria for identifying eco-innovative companies, two databases were requested: one formed by innovative companies that declared “high” or “medium” importance in reducing the impact on the environment, hereinafter identified as ECO, and another composed of companies that answered “low” or “not relevant” relevance, identified as INO. The objective here was to draw a comparative profile between ECO and INO, based on a selection of variables from Pintec’s general block, which were considered relevant for the purpose of the investigation. Data were derived from the extractive and manufacturing sectors, for the period 2015–2017.

The second stage involved the development of cluster heatmaps to examine information from the special EI set. The cluster heatmap statistical tool was developed computationally by Galili et al. [49], using the R language [50]. In simple terms, the method is applied to large data matrices, for viewing patterns and creating dendrograms for the definition of clusters.

The heatmap cluster method is based on the application of an algorithm, which provides a structure in a series of clusters, and clusters of clusters, of data examination. In other words, unlike other clustering methods, here the algorithm determines the number of clusters. These algorithms can follow different logics, the most common is hierarchical cluster analysis (HCA). This logic combines objects that are closest to each other until all objects are joined in one single cluster, which will be separated from other furthest objects. To analyze which drivers and impacts were more (or less) important for eco-innovative companies of different sectors, we applied the “complete linkage” method (for HCA) to calculate distances between aggregates (or dissimilarity between clusters). This method determines the distance (or dissimilarity) between two clusters as the distance between the furthest two objects from each cluster. Thus, the ordering method allows similar rows (or columns) to be placed together in the graph. The “complete linkage” method results in compact and homogeneous clusters [51], which we consider adequate for our study.

For the construction of these clusters, two questions from Pintec were selected: N°196, which asked companies to highlight the factors that contributed to their decision to introduce innovations that would generate environmental benefits, and N°105 (sub-items 1 to 5), which requested companies to indicate the relevance of the impact on the environment of the innovations implemented. For these sub-items, only “high” or “medium” graduations were considered.

The heatmap method is performed in three phases [49,51]: treatment of the data matrix; definition of similarity; and determination of the serialization of rows and columns matrix (dendrogram). The first concerns the organization of data. In this phase, two matrices of standardized data in “z” scores were composed by economic activity (two sections and 24 NACE divisions). As the number of companies in the sample is highly varied between activities, it was necessary that the data be standardized. Thus, the matrices were as follows: EI drivers, composed of 10 EI inducers and 26 economic activities, and EI impacts, formed by 5 observed effects and 26 economic activities (Figure 2). In the second, the type of similarity between the observations in each cell (row and column) was defined. In the third and last phases, the ranking of the data in the rows and columns was determined. Furthermore, the ordering of the data (scale) was carried out according to its distribution in the columns. Therefore, the colors and the order of the observations were distributed to highlight the sectors that had the highest values in each variable.

Industrial activities (2 sections + 24 divisions NACE)	Eco-innovation drivers matrix	Eco-innovation impact matrix
<ul style="list-style-type: none"> • Extractive (mining and quarrying) • Manufacturing <ul style="list-style-type: none"> • Man. food products • Man. beverages • Man. tobacco products • Man. textiles • Man. wearing apparel • Man. leather and related products • Man. wood and prod. wood and cork • Man. paper and paper products • Printing and reproduction of recorded media • Man. coke and refined petroleum products • Man. chemicals and chemical products • Man. pharmaceutical products and preparations • Man. rubber and plastic products • Man. other non-metallic mineral products • Man. basic metals • Man. fabricated metal products • Man. computer, electronic and optical products • Man. electrical equipment • Man. machinery and equipment • Man. motor vehicles, trailers and semi-trailers • Man. other transport equipment • Man. furniture • Other manufacturing • Repair and install. machinery and equipment 	<ul style="list-style-type: none"> • Voluntary actions (VACT) • Meet the necessary requirements for the consolidation of public contracts (RQPC) • Codes of good environmental practices in the sectors which it operates (COGP) • Market demand (real or potential) for environmental innovation (MKT D) • Availability of government support, subsidies or other government financial incentives for environmental innovation (GOVS) • High costs or energy, water or raw materials (HCTS) • Improve the company's reputation (REPT) • Existing environmental standards or taxes on contamination (EEST) • Environmental standards or taxes that may be introduced in the future (FEST) • Others (OTRS) 	<ul style="list-style-type: none"> • Recycling of waste, wastewater or materials for sale or reuse (RECY) • Reduced contamination of soil, water, noise or air (RCON) • Reduction of the company's CO₂ footprint (CO₂ production) (RCO2) • Total or partial replacement on energy of fossil fuel with renewable energy sources (RENG) • Substitution, in whole or in part, of materials with others that are less pollutants or hazardous (SBSM)

Figure 2. Drivers and impacts of eco-innovation, and industrial activities to generate heatmap matrices.

4. Results

As highlighted in the concept of EI, environmental innovation occurs within the company and follows the characteristics of innovations in general, except for the positive effect it has on the environment. In this sense, according to the guidelines of the Oslo Manual [52] applied at Pintec [44], (eco)innovation corresponds to any product, process, or organizational form that is new to the company, even if it is known in the market. This section has two objectives: to draw a comparative profile between the ECO and INO companies, and to examine the drivers and impacts of EIs on ECOs.

4.1. Comparative Profile of ECO and INO Companies

The last edition of Pintec surveyed 39,329 innovative companies (all economic sectors covered by the survey); out of these, 13,365 (34.0%) said that innovation allowed them to reduce the environmental impact with “high” and “medium” importance. In extractive activity, there were 143 eco-innovative companies, while in manufacturing, there were 12,334 [45].

As shown in Table 2, the rates of innovation—total and sectorial—for ECOs were lower, as expected, since they represent a little more than a third of innovative companies. However, when analyzing the rate of innovative intensity (the ratio between the amount spent on innovation activities and the company's current net revenue), a slightly higher effort is observed in the ECOs, mainly in-house R&D activities [18,42,53]. As EIs represent a very dynamic field in which knowledge is rapidly changing, it is observed that R&D activities, as well as cooperation with research centers and universities, are more important compared to other innovations without environmental benefits [35,37,53–55]. Furthermore, as EIs, particularly products and processes, are characterized by a high degree of innovation, the cost of new equipment, software, and marketing activities is more relevant when compared to other innovations [8,54].

Table 2. Number, innovation rate, and innovative intensity rates of eco-innovative (ECO) and innovative (INO) companies, by selected economic sector, Brazil, 2015–2017.

Sectors	Innovation Rate		Innovative Intensity Rate				N° of Companies		
			Total		In-House R&D Activities				
	ECO	INO	ECO	INO	ECO	INO	ECO	INO	Total
Extractive	6.2	8.4	1.2	1.9	0.7	0.5	143	193	336
Manufacturing	12.3	22.0	1.6	1.1	0.6	0.4	12,334	22,062	34,396
Total ⁽¹⁾	11.4	22.2	1.8	1.6	0.9	0.5	13,365	25,964	39,329

Source: Own elaboration, based on IBGE [45]. Note: (1) Includes all sectors of the survey.

The degree of novelty of product and process innovation is an important measure, as it reflects the radical nature of innovation. While national rates refer to innovations for the domestic market already developed in the world market, world rates refer to the most substantial innovations, which are also new abroad (Figure 3).

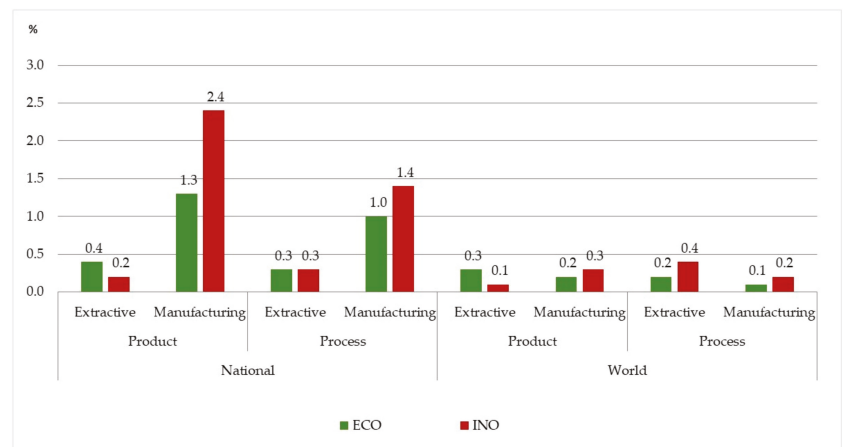


Figure 3. Rate of product and process innovation in industrial sectors of eco-innovative (ECO) and innovative (INO) companies, according to the degree of novelty for market, Brazil, 2015–2017. Source: Own elaboration, based on IBGE [45].

When comparing these rates in groups of companies, there are interesting elements. In turn, in the world segment, although they present a higher index only in product innovation in the extractive sector, the difference between the two groups is smaller when compared to the national segment, indicating that the ECO and INO are practically at the same level of novelty. On the other hand, in manufacturing, the superiority of the INO in both markets is undeniable. In summary, the 2015–2017 portrait shows that Brazilian EIs generated a higher impact on extractive activities. This is positive, given that this sector is notoriously known for its high polluting potential and its ability to deplete non-renewable resources. Furthermore, incremental technologies predominate in Brazilian EIs, which has been observed in studies of environmental innovation in other countries [8].

The benefits observed with the innovations are relevant aspects for the discussion about the drivers and impacts of EIs, as they highlight a double stimulus effect: the inducing element reflects on good results that corroborate with the induction and encourage it. To address this issue, only companies that expressed “high” or “medium” importance were considered. In addition, these gains were grouped into three categories: competition (related to better market positioning), production (related to greater efficiency in the production process) and protection (linked to compliance with norms and standards). The

point that draws attention is the greater perception of ECO about the benefits generated by innovation (Figure 4). The only benefit in which INO had greater relevance was the opening of new markets in the extractive activities.

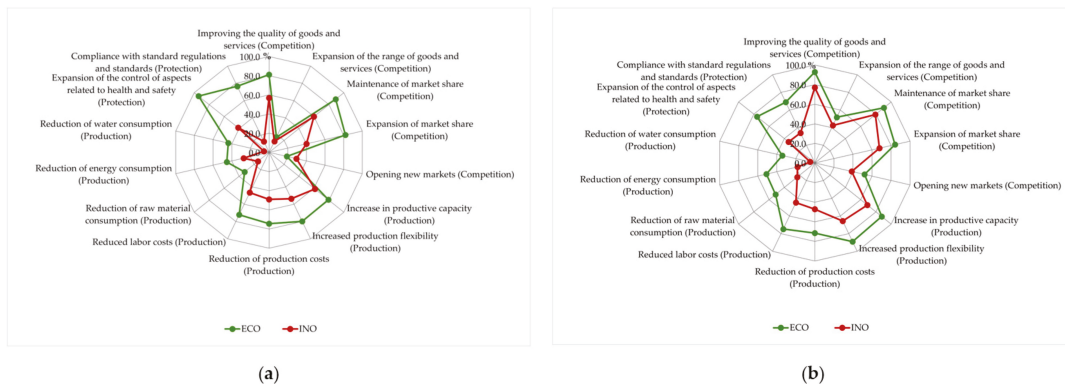


Figure 4. Benefits highlighted by eco-innovative (ECO) and innovative (INO) companies, in the extractive (a) and manufacturing (b) sectors, according to category, Brazil, 2015–2017. Source: Own elaboration, based on IBGE [44]. Note: data of companies that attributed “high” or “medium” importance to the benefit.

The main differences in favor of ECO were found in the categories of production and protection. In manufacturing (Figure 4b), the gains from the reduction in the consumption of inputs, energy, water and raw materials were the most relevant, and, in the protection category, both benefits from compliance with norms and standards were accentuated. In extractive sector (Figure 4a), the advantages of competition stood out, particularly the gains from the expansion and maintenance of the market share. In the case of the INOs, it is worth emphasizing that, despite manifesting benefits of reducing the consumption of water, energy, and materials, they declared that the innovation had a low or non-relevant impact on the environment. Here, the hypothesis is that the benefits of the reductions were, above all, the result of a cost saving strategy. Therefore, ECOs expressed the benefits of innovation more intensely—not only those that positively interfere in the environment (such as the decrease in the quantity of inputs), but also others capable of promoting them to more competitive environments. Although it may seem contradictory, eco-innovative companies appear to be less dependent on stricter regulation than more passive companies. Therefore, the adoption of more subtle measures—voluntary actions, eco-audits, eco-labels, and codes of good practice—may be sufficient for pioneering EI companies [23]. However, EIs depend more on environmental rules than other innovations [37,54,56].

Finally, other pertinent information concerns the obstacles highlighted by companies. These data are particularly useful to develop, apply, and monitor policies to foster innovation. To assess them, the problems were grouped into three types of barriers: economic (emphasizing the availability and sources of monetary resources), technique (focusing on the direct factors of production and innovation) and institutional (bringing together a variety of actors and forms of interaction) (Figure 5).

The results of barriers to innovation were quite different among industrial activities. In extractive sector, ECOs were shown to be less susceptible to problems, unlike INO (Figure 5a). The exception was in the excessive economic risks item, in the economic barrier. Despite being the most recurrent problem among ECOs, the other two obstacles to the same barrier—high costs of innovation and scarcity of appropriate sources of financing—were not perceived with the same intensity. One speculation is that this phenomenon may be associated with the application of measures to support EIs in extractive activities, such as cheaper access to credit or other financing options, which provide, in return, better environmental performance, which is unknown or even devalued by the sector’s

INO. In general, financial barriers (imperfect financial markets, absence of financial assets, scalability, and even weak environmental rules) hinder the development and the diffusion of EIs [28].

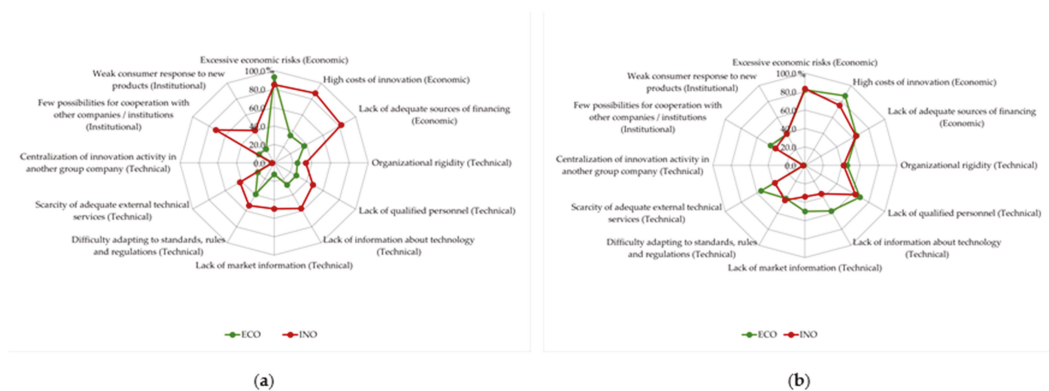


Figure 5. Obstacles highlighted by eco-innovative (ECO) and innovative (INO) companies, in the extractive (a) and manufacturing (b) sectors, according to category, Brazil, 2015–2017. Source: Own elaboration, based on IBGE [44]. Note: data of companies that attributed “high” or “medium” importance to the obstacles.

When examining the manufacturing industry, ECOs indicated the greatest sensitivity to barriers to innovate (Figure 5b). The economic barrier was the most accentuated and the high costs of innovation stood out. In the technical barrier, the most prominent problems were the lack of qualified personnel (also shared by the INO) and the lack of information about technology. This last problem, added to the lack of information on markets and the lack of adequate external technical services, expressed the greatest differences between the two groups of companies. Here, the hypothesis was that ECOs constitute a more specific group of companies, which demand more advanced knowledge and technologies, aimed at a green vanguard [35]. Regarding institutional barriers, the intensity was practically the same in ECO and INO, with a greater signal for the scarce possibilities of cooperation with other companies or institutions in the case of eco-innovators. However, as reported in the literature, in general, the EIs depend more on external sources of knowledge and information than other innovations [54,57].

4.2. Analysis of ECO-Innovation Drivers

Although the literature review exposed a broader set of EI drivers, the investigation analyzed the factors defined by Pintec [45] as follows: voluntary actions (VACT); government support (GOVS); codes of good environmental practices (COGP); market demand (MKTD); high costs of energy, water or raw materials (HCTS); existing environmental standards or taxes on contamination (EEST); environmental standards or future taxes (FEST); company reputation (REPT); public contract requirements (RQPC); and others (OTRS) (Table 1 and Figure 2). The data refer to the extractive and manufacturing industries, as well as the 24 sectors of the latter.

Figure 6 (see interactive heatmap in Figure S1) exposes two clusters: the first, indicated by the column dendrogram (horizontal-axis), groups the EI drivers according to their frequency in the industrial sectors, while the second, line dendrogram (vertical-axis), brings together industrial sectors with a similar distribution of drivers. In both cases, the intensity of the orange color indicates the greater influence of the drive, with the scale in number of standard deviations.

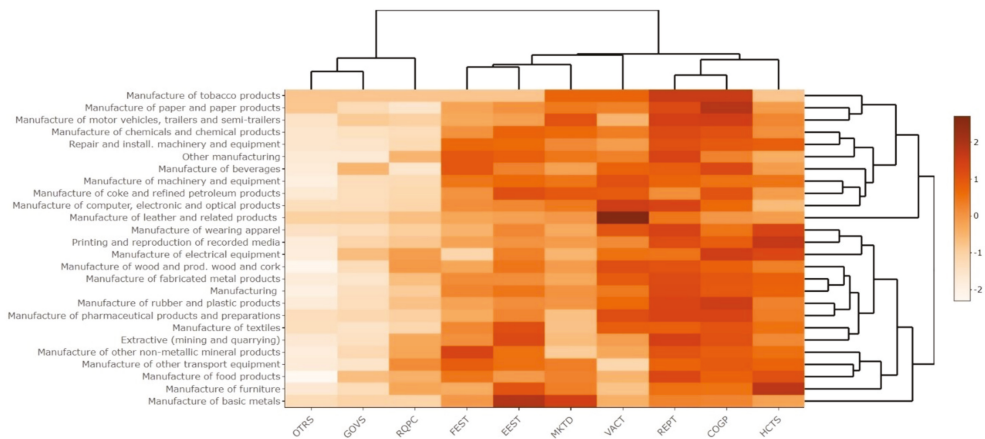


Figure 6. Drivers of eco-innovation on eco-innovative companies by sectors of the extractive and manufacturing industries, Brazil, 2015–2017. Source: Own elaboration, based on IBGE [45].

The analysis of the driver cluster shows distinct scales of value among the drivers of EI. The first group, to the left of the heatmap, places the drivers that contributed least in the decision to develop innovations with environmental gains. Both the OTRS (for which no additional information is given) and the GOVSs had close weights; in turn, the RQPCs were mentioned a slightly more. Government support, subsidies, and other incentives for EIs (technology push) seek to boost the development and application of technologies, processes, products, and organizational procedures that are less aggressive to the environment. Regulatory pull requirements are an environmental policy measure that conditions aspects of the company's ecological conduct to the conclusion of business with the government.

The second group, on the right, was divided into two branches. The first branch grouped EEST and FEST (regulatory pull/push), which presented motivations such as the MKTD driver (market pull). These, in turn, were like those of VACT (market pull), which represent a set of company actions, with the purpose of creating internal practices of good environmental conduct (such as the proper disposal of electronic waste). Here, there is a point to be highlighted regarding the importance given to environmental standards, whether existing or to come. Studies have indicated that EIs are more dependent on regulations than other innovations [37,56–59]. However, in the case of Brazil, this was not verified, either by the environmental norms or by the requirements for public contracts, which are both instruments of environmental policy. The second branch reflects the combination of the three main drivers: REPT and COGP (market pull), and HCTS (cost-savings). The reputation is related to the adoption of a green communication strategy, such as the creation of an eco-friendly image, which is also very conducive to stimulate marketing innovations. The codes of good practice comprise tacit measures and agreements that, although not mandatory, act as a type of rule of behavior for companies in each sector, or that are part of a production chain. These drivers showed the highest values. The REPT and COGP are drivers influenced by institutional pressures, which help guide R&D efforts for environmental protection strategies [34]. In turn, the HCTS is a very prominent driver in the literature, indicating that EIs apply far more cost-saving or energy-saving strategies than other innovations [23,30,37,54]. Furthermore, if, on the one hand, firms tend to initiate EI projects in response to market pressures, on the other hand, greater investments in EIs are encouraged by other determinants, such as HCTS [38].

The analysis of the cluster of EI drivers, according to the sector (line dendrogram), allows us to raise, albeit with caution, some hypotheses. It is important to note that the sectorial composition involves differentiated activities included within the same eco-

nomie division; that is, there are different characteristics regarding the intensity of technology/labor, international market orientation [18,60,61], degree of transformation, position in the production chain [39,62], and the size and share capital of the company [18], among other aspects.

The distribution of industrial activities was segmented into two sub-clusters, each formed by two secondary groups, which branched into small groups. In the first sub-cluster—formed by the first 11 activities arranged in the upper part of the heatmap—particularities were identified that may elucidate the weight of certain EI drivers. An example was the first three sectors: tobacco; paper; and motor vehicles, trailers and bodies. In these activities, EIs were motivated mainly by market pull, REPT, and COGP drivers. Similarly, they are exporting sectors, subject to different types of pressures, such as customers, stakeholders and other actors that relate the activity to others downstream in the production chain (for example, tobacco and forest monocultures). The company's position in the production chain can influence the willingness to eco-innovate, as well as its orientation towards the foreign market [17,18,39]. Another divergent sector was the preparation of leathers and the manufacture of leather goods, travel goods, and footwear, with a strong weight of the driver of voluntary actions. One hypothesis is that, although Pintec does not provide data on the type of product, EIs were potentially of an organizational type, given the relevance of internal environmental protection practices. Based on studies focused on sectors with high polluting potential, it is possible to highlight some points. This is the case for the manufacture of chemicals and energy-intensive industries, which often carry out more EIs due to regulatory pressure or high energy consumption [26,37,42]. Two other activities more sensitive to the regulatory pull/push determinants was the manufacturing of machinery and equipment and the manufacturing of coke, petroleum products, and biofuels.

The second sub-cluster connected 13 activities, plus the extractive and processing industries. In the case of extractive activities, there was a prevalence of existing environmental standards (EEST), (regulatory push/pull), reputation (REPT) and codes of good practice (COGP) (market pull), while in manufacturing, the main drivers were reputation and codes of good practice (both market pull), and the high costs of energy, water, and raw materials (HCTS) (cost-saving). The sector that came closest to the average for manufacturing was metal products. In turn, the activities most influenced by the cost-saving driver were furniture, wearing apparel, printing and reproduction of recordings, and electrical equipment. Strategies to reduce costs and use resources more efficiently are highly significant for eco-innovative companies, even more than for other innovators [29]. The codes of good practice mainly guided EIs in the sectors of rubber and plastics, pharmaceutical products and preparations, and textiles. Finally, basic metals were the most induced to eco-innovate by existing environmental rules.

4.3. Analysis of ECO-Innovation Impacts

Like the analysis of drivers, the examination of the impacts was based on the list of effects on companies (Table 1 and Figure 2), as follows: substitution of materials with others that are less contaminating (SBSM); replacement of energy from renewable fossil fuels (RENG); reduction in the contamination of soil, water, waste, or air (RCON); recycling of waste, wastewater, or materials, for sale or reuse (RECY); and reducing the CO₂ footprint (RCO₂). For each effect, the company indicated the degree of company, being that they were computed only as “high” or “medium” manifestations on impact.

Figure 7 (see interactive heatmap in Figure S2) associates two clusters: one, referred to by the column dendrogram (horizontal-axis), which groups the impacts of EIs according to their occurrence in the industrial sectors, while the other, line dendrogram (vertical-axis), approximates industrial activities with a similar arrangement of impacts. In both clusters, the stronger green color corresponds to the greater relevance of the impact, with the scale being the number of standard deviations.

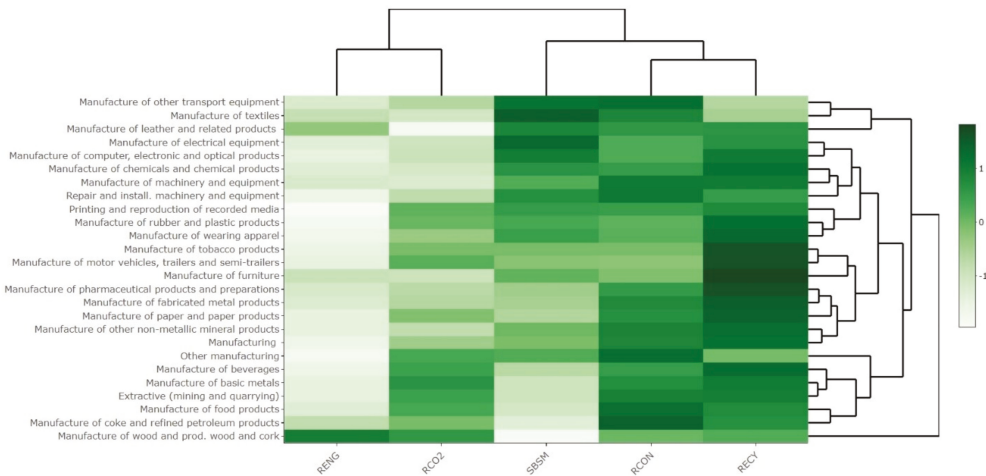


Figure 7. Impacts of eco-innovation on eco-innovative companies, by sectors of the extractive and manufacturing industries, Brazil, 2015–2017. Source: Own elaboration, based on IBGE [44].

The scale of relevance of environmental impacts perceived by eco-innovative companies was segmented into two sub-clusters. The grouping to the right of the heatmap highlights the most observed impacts. The industrial companies realize that their environmental innovations have made it possible, above all, to recycle waste, including wastewater and materials for reuse (RECY). The reduction in the contamination of soil, water, noise, or air (RCON) was the second most relevant. A common element in the two effects was the similar level of importance across sectors. This is the characteristic that links the two effects on the same branch. At another level was the substitution of raw materials for others that are less harmful to the environment (SBSM). The second sub-cluster brought together the two less relevant effects: the reduction in total CO₂ production (carbon footprint), RCO₂, and the replacement of fossil energies with renewable sources (RENG). Although both impacts are important to mitigate damage to the environment, this drew attention to the low level of energy change, by green technologies for energy generation. Furthermore, it is pertinent to mention that EIs that reduce CO₂ emissions are highly dependent on subsidies, basic research, and public technology programs [8].

The examination of the impacts by sector of activity indicated a very distinct cut, formed by a large group with three branches and a group of only one activity—in this case, that of wood products. This isolated position of the sector is due to the high frequency of impact in four of the five predicted. In addition, this activity showed the greatest manifestation regarding energy transformation, using cleaner sources of energy generation (RENG). In general, the other sectors had between two or three more important impacts. Regardless of this provision, it is important to reinforce the reservations regarding the characteristics of each sector, which make it possible to establish only a few deductions. One of them was the lesser relevance of the effect of substituting materials for others that are less harmful to the environment (SBSM) in some sectors, such as wood products; coke and refined petroleum products; food and beverage products; basic metals; and extractive activities. All these activities depend heavily on specific materials for which there are no direct substitutes. This is the case for water for the beverage and food industry; wood for products of this nature; coke, oil, and sugar cane (or other materials used for this purpose, such as soy, corn, and biomass) for fuels; and minerals for extraction activities.

4.4. Drivers, Impacts and Innovation Variables: Correlated Effects

To complete the heatmap analysis, we calculated the correlations among the drivers (10), impacts (5), and other selected innovation variables (91) captured by Pintec (Appendix A). The purpose of this exercise was to establish a profile of eco-innovators, which could guide actions to encourage EI. The results of this exercise are shown in Figure 8.

VARIABLES	DRIVERS										IMPACTS				
	EEST	FEST	GOVS	MKTD	REPT	VACT	COGP	HCTS	RQPC	SBSM	RENG	RCON	RECY	RCO ₂	
Innovative intensity rate	No	No	No	No	No	No	No	No	No	0.521 *	No	No	No	No	
Main responsible product innovation - the company	No	-0.750 **	No	No	No	No	No	No	-0.549 *	No	No	No	0.545 *	No	
Main responsible product innovation - another company and institute	No	0.601 *	No	No	No	No	No	No	0.652 **	No	No	No	No	No	
Main responsible process innovation - the company	No	-0.565 *	No	No	No	No	No	No	No	No	No	No	No	No	
Main responsible process innovation - another company and institute	No	-0.527 *	No	No	No	No	No	No	No	No	No	No	No	No	
Benefits of innovation - maintenance of market share	No	No	No	No	No	No	No	No	No	No	No	No	No	0.525 *	
Benefits of innovation - expansion of market share	No	No	No	No	No	No	No	No	No	0.525 *	No	No	No	No	
Benefits of innovation - reduced labor costs	No	No	0.509 *	No	No	No	No	0.681 **	No	No	No	No	No	No	
Benefits of innovation - reduction of energy consumption	No	No	0.554 *	No	No	No	No	0.649 **	0.567 *	No	No	No	No	No	
Benefits of innovation - expansion of the control of aspects related to health and safety	No	No	No	No	No	No	No	No	No	No	No	0.647 **	No	No	
Benefits of innovation - compliance with standard regulations and standards	No	No	No	No	No	No	No	No	No	No	No	No	0.610 *	No	
Barriers of innovation - scarcity of adequate external technical services	No	No	No	No	No	No	No	No	0.520 *	No	No	No	No	No	
Information sources - another company in the group	No	No	No	No	No	No	0.560 *	No	No	No	No	No	No	No	
Information sources - professional training centers and technical assistance	No	No	No	No	No	No	No	0.528 *	No	No	No	No	No	No	
operation - suppliers	No	No	No	No	No	0.530 *	No	No	No	No	No	No	No	No	
Organizational Innovation - management technique	No	No	No	No	No	No	No	No	No	0.510 *	No	No	No	No	
Organizational Innovation - environmental management technique	No	No	No	0.528 *	No	No	No	No	No	No	No	No	No	No	
Eco-innovators that produced renewable energy	No	No	No	No	No	No	No	No	No	0.564 *	No	No	No	No	
EEST	No	0.604 *	No	No	No	No	No	No	No	No	No	No	No	No	
FEST	0.604 *	No	No	No	No	No	No	No	No	No	No	No	-0.606 *	No	
REPT	No	No	No	No	No	No	0.828 **	No	No	No	No	No	No	No	
COGP	No	No	No	No	No	0.828 **	No	No	No	No	No	No	No	No	
HCTS	No	No	No	No	No	No	No	No	0.616 *	No	No	No	No	No	
RQPC	No	No	No	No	No	No	No	0.616 *	No	No	No	No	No	No	
RCON	No	No	No	No	No	No	No	No	No	No	No	No	No	0.519 *	
RECY	No	-0.606 *	No	No	No	No	No	No	No	No	No	No	No	0.560 *	
RCO ₂	No	No	No	No	No	No	No	No	No	No	0.519 *	0.560 *	No	No	

Figure 8. Correlation coefficient—selected variables. Note: No—Not significant; * significant at 1%; ** significant at 0.1%.

Among the aspects observed, one was that eco-innovators motivated by REPT were also influenced by COBP, both drivers of market pull. In EEST and FEST, and in the HCTS (of energy, water, or raw materials) and RQPC, the same happened. In the latter—drivers of a different nature—it is likely that when the company eco-innovates looking for cost-saving, it is also more attentive to other market opportunities, such as meeting environmental conditions to supply products or services to the public sector.

In terms of impacts, the reduction in CO₂ emissions (RCO₂) was linked to two other effects: the RCON (grouping soil, water, waste, or air) and the RECY (contemplating waste, wastewater, or materials). ECO-innovators, who showed a decrease in their carbon footprint, also exhibited a reduction in contamination, in addition to the effects of recycling.

In RECY, there was an inverse correlation with FEST. This result was interesting and corroborates with previous studies. As already noted, recycling is generally associated with the use of more widespread and less complex technologies [37,63]. In this sense, when an eco-innovative company is guided by environmental standards or future taxes, it expects regulations to become more restrictive, and will probably prefer to develop innovations with greater effect in reducing contamination, which recycling practices are more limited in achieving.

The correlations with other innovation variables highlighted pertinent elements. In drivers, eco-innovators induced by FEST normally have another company and institute as the main responsible for product innovation. This relationship reinforces the fact that eco-innovators are more dependent on external agents, especially when there is an expectation of greater rigidity of environmental standards [37,42,57]. In contrast, these standards or taxes were inversely related when the main actor responsible for product innovation is the company. In process EIs, regardless of the main innovation agent, the relationship with

FEST remains the opposite. In other words, companies guided by these standards tend not to eco-innovate in the process.

Government encouragement (GOVS) was associated with reduced labor and energy costs. Moreover, those motivated by market demand (MKTD) tended to adopt environmental management techniques. Recalling that these techniques involve, among other aspects, an environmental communication policy aimed mainly at answering questions from consumers and stakeholders about the company's environmental behavior, this result reinforces the importance of environmental management systems for EIs [34]. In turn, companies that were guided by voluntary efforts (VACT) tended to cooperate with suppliers. A similar observation was made between the COGP and the relevance of another company in the group in the sources of information. In these two situations, there was a greater willingness to establish links downstream of the production chain or with companies in the same sector. It was interesting to note that the high cost driver (HCTS) was related to the benefits of reducing labor and energy costs, and to sources of information with professional training and technical assistance centers. Regarding RQPC, these are linked to the condition that the main executor of the product EI is another company and institute, the benefits of decreased energy consumption, the absence of adequate external technical services, and conversely, when the main executor of product innovation is the company.

In respect of impacts, the replacement of materials (SBSM) was associated with the rate of innovative intensity of the companies, their expansion in the market and the application of management techniques. The substitution of energy (RENG) was related to the production of renewable energy. The RCON tended to increase the control of aspects related to health and safety. The recycling effect was mainly observed when it led to the framing of regulations and standards, and when the main developer of the product innovation was another company and institute. Finally, eco-innovators who saw a reduction in their CO₂ footprint more directly perceived the company's maintenance gains in the market.

5. Discussion

To promote the development of EIs, some aspects must be considered. The first is the fact that they need much more stimulation than other innovations, mainly regarding access to external sources of knowledge and information, the granting of subsidies and the support of public technology programs [8,54]. In the case of Brazilian eco-innovative companies, the scarce possibilities for cooperation with other companies or institutions, the lack of information about technology and the market, the scarcity of external technical services and the high costs of innovation were recurrent impediments in manufacturing.

Although this relevance has not been observed in extractive activities, an addressing investment to promote EIs would be very auspicious. In developing countries such as Brazil, the support of universities and research centers, especially in the environmental and technological areas, can simultaneously help to overcome economic and environmental problems, and can provide opportunities for EIs [37]. As the study indicated, the proximity to other external agents proved to be relevant for eco-innovators motivated by the reduction in high costs. A similar observation was made in the relationship between voluntary actions and cooperation with suppliers.

However, the effectiveness of actions such as this depends greatly on the degree of articulation and commitment between the actors involved. The government has a key role in this process, mainly the public institutions responsible for industrial, innovation and environmental policies [15]. As highlighted in the study, even with the encouragement of some actions, there are important corrections to be made. A good example is the eco-innovators who, even induced by the requirements of public contracts, face the lack of adequate external technical services.

The synergy between the instruments of these policies can increase environmental engagement in the economy, involving companies and consumers, the public and private sectors, universities and research centers, institutional and civil society representatives. The

goals set out in SDG 9 are linked to this environmental commitment. The modernization of infrastructures and the improvement of the industry to make them sustainable, the increase in scientific research and technological capabilities of the industrial sectors, and the encouragement of innovation are goals that are part of the same transformation circuit.

From the perspective of companies, they need to develop skills in the scope of sustainability, improving products, processes, and organizational and management forms. For example, initiatives related to organizational innovations have indicated interesting links with the drivers of market demand and the exchange of materials for others polluting less.

Despite being an internal task that must be undertaken in the long term [22], the benefits achieved by EIs are an incentive both for eco-innovators to advance in new projects and for other companies to realize the advantages of eco-innovating, valuing in its innovation strategy the reduction in environmental impacts. As the study revealed, although EI requires greater effort on the part of eco-innovators—as indicated in the index of in-house R&D activities—they perceived with greater emphasis the gains in the three categories analyzed, competition, production, and protection.

The analysis of drivers and the impacts of EIs provided interesting insights. Examining the drivers, the conclusion was that EIs in Brazil still receive scarce attention from the public sphere. This was evident in the results of government support drivers (technology push), requirements for public contracts (regulatory pull), and environmental standards, existing or expected (regulatory pull/push), which were less relevant than the other inducers. This result is in line with other studies, such as Mazzucato and Penna [16], who pointed out a lack of cohesiveness in the Brazilian innovation system, as we have seen at the beginning of this article, namely through aspects that show the difficulties in creating innovation policy instruments aimed at environmental innovation, in dialogue with industrial and environmental policies. Here, public financial support is essential to encourage EIs. On the other hand, the greater representativeness of the company's reputation drivers and codes of good practice (both market pull), and high cost of materials (cost-saving), signals that the development of EIs is highly associated with a market response. The analysis allowed us to make some hypotheses based on the formation of sub-clusters, such as the connection of certain drivers with the sector's level of exposure in the foreign market, or the position sector in a broader production chain.

The examination of the impacts resulting from EIs was equally interesting, either by complementing the analysis of the inducers, or by indicating the types of EI results most observed in the country. The most relevant effects were the recycling of waste, the reduction in contamination, and the replacement of materials with others that are less harmful to the environment. In contrast, the least verified were the reduction in carbon footprint and the replacement of non-renewable sources of energy with cleaner sources.

Although Pintec does not inform the purpose of the EI, it is desirable to establish some considerations. Among them is the small relevance of adopting clean energy. The transition to a more sustainable model is strongly linked to this substitution, as stated in SDG 7, which aims to increase the share of renewable energy by 2030. Efforts to reduce energy consumption require more advanced technologies and higher R&D expenditures. In Brazil, an interesting initiative is the adoption of a solar energy system for public lighting, an EI implemented by the public sector [63]. For this reason, the development and use of clean energy occurs mainly in central countries, while less technologically demanding options, such as recycling, predominate among semi-peripheral and peripheral countries [19]. This last situation was verified in Brazil. In EIs, the effects associated with more widespread and less complex technologies, such as the recycling of waste, wastewater, or materials, prevailed. This consideration can be extended to the effects of reducing the contamination of soil, water, air and noise, which tend to represent a first stage of EI [39], associated with the use of end-of-pipe, which seeks to improve the quality levels of these elements, through the application of filters or other devices for this purpose. It is important to note that EIs are most often associated with cleaner production measures, unlike end-of-pipe technologies, that reduce environmental damage without changing the production process [64].

Focusing on the sector, a feature of semi-peripheral countries such as Brazil is the high representativeness of sectors of medium or low technological intensity, many of which also have high levels of polluting potential. Despite sharing these characteristics, this does not mean that they are homogeneous; quite the contrary, there is a variety of aspects that differentiate them—market orientation, technological intensity, labor intensity and qualification, and production chain, among others. Hence, the technological options and EI opportunities will differ from sector to sector. Thus, it is presumed that an available part of the stock of clean technologies belongs to a given sector. Therefore, the characteristics of each production activity guides both existing technological opportunities and influences their degree of innovativeness and, likewise, affect the chances that EIs are developed and adopted [39]. This is a key point to be considered in the measures and actions to promote EIs.

Here, it is interesting to note the relationship, or lack thereof, between the sectors with the same profile in drivers and EI impacts. In groups of companies with the same profile of drivers and impacts, it was not possible to detect similarities in technological terms. Particularly in the drivers, it was expected that the sectors of the same group had the condition of related variety [65], i.e., the firms of different sectors had some cognitive proximity and, consequently, intersectoral complementarity that could explain the similar innovative profile. However, the possibility must be raised that this diversity is simply random and, therefore, there is no justification for this. ECO-innovative companies follow an “ecological” technological trajectory for specific reasons, shared in their sector, and which are not present in units from other sectors of the same profile defined by heatmaps.

6. Conclusions

It is increasingly urgent to establish a new model of production and consumption that is sustainable. An alternative to achieve this objective and advance in the development of a sustainable technological model is to encourage EIs. However, semi-peripheral countries such as Brazil will have to deal with their technological limits to access this new green model. Given this scenario, the study set out to establish an overview of EI in the country, with the aim of bringing elements to expand the dialogue among innovation, industry and environment. The study indicated that eco-innovators represent a third of all innovators. As highlighted, these companies have shown greater effort to innovate and greater susceptibility to the benefits and obstacles of innovation; their eco-innovation strategy are mainly driven by market factors; and the impacts are mainly associated with the use of more widespread and less complex technologies.

At the global level, numerous ways to encourage more sustainable production and consumption are discussed. One way is to rethink the economic incentives for EI. An interesting measure is the implementation of industrial certifications and credits that guarantee that the production processes comply with environmental requirements [15].

Semi-peripheral countries such as Brazil can overcome the technological gap by relying on emulation from mission-oriented innovation policies [66] that, for example, can promote an assignment, such as diminishing carbon emissions in a specific period, or a transformative innovation policy [67] that highlights an integrated and systemic approach, considering the negative social and environmental effects of innovation in its framework. Both cases highlight the promotion of investments in innovation (especially in EIs) with the leading role in this process [68].

These types of policy can be carried out through various instruments, which can be on the supply side, such as tax incentives for R&D, or on the demand side, such as public procurement policies, or even by both orientations (supply and demand), such as technical standards [69].

However, the analysis undertaken here may highlight some interesting preferential paths. Returning to the results of EI drivers, among the most valued inductors were reputation and codes of good practice. Both inductors—with a strong correlation as indicated by the study—are tacit and, therefore, not mandatory. Thus, two policy instruments seem

ideal for raising awareness and impelling (or compelling) more companies to innovate in environmental terms. Exercising influence on both the supply and demand sides, these instruments can be used for technological forecasting and regulation.

Technological forecasting aims to sensitize and alert public and private managers about trends in technological trajectories at national and global levels and, at the same time, about the benefits of considering these trends. As previously mentioned, the theme of EIs or sustainable technological development is in the list of global megatrends, highlighting the strong link between technological changes and the environmental dimension [5,7,10,11,70]. It is important to emphasize that this instrument also intends to provoke improvements in the discourse in general, which is fundamental for changing an outdated technological trajectory. On the other hand, the regulation instrument—also correlated—has an important role in the same direction as technological forecasting, but on a compulsory basis. In short, regulations seek to increase the demand for (environmental) innovations and improve the overall technological structure.

In addition to this pair of policy instruments, many others would apply. Among those that should be highlighted are those linked to the promotion of interaction and learning at regional and national scales [69]. Directed to the offer, three instruments are highlighted here: agglomeration policies, support for collaboration, and innovation networks. All of these emphasize the importance of the agents' interdependence to innovate in new and disruptive themes to reach more advanced levels of general technological development. For example, it is worth mentioning the case of eco-industrial clusters, which can be fostered by policies, where the waste from one plant is used as input by another plant, etc. [71], forming clusters of sustainable industries, whose production is associated with the circular economy. The EIs represent a type of transformation process, capable of creating a socioeconomic system based on the idea of the circular economy [72]. In this sense, it is very pertinent to examine whether innovative institutional contexts—regional and national—encourage environmental technological change and, therefore, the EIs [73].

Another interesting perspective is to analyze the phenomenon of the development and diffusion of EIs from the territory [74,75]. Although (eco)innovation requires an analytical knowledge base [76], which results in closer links with universities and the formation of complex international knowledge exchange networks [77], it also requires a synthetic knowledge base [76], which is linked to knowledge and skills based on local, regional and national experience [77].

As a research agenda, we consider that this study can stimulate further analysis. The expectation is that the presented sectorial portrait will serve as an initial stage to investigate groups of sectors that share similarities, such as high polluting potential or belonging to certain production chains. Here, case studies can provide valuable information, particularly to guide eco-innovation policies. Another further research agenda is the analysis of related variety, or systems of related firms in eco-innovation issues from a regional development perspective [65], for example: occupational structures as information networks and also through the flow of labor among industries; the technological relatedness among industries, a fundamental issue for developing countries [78]; or research relationship among individuals or scientific institutions. In all these cases, the relatedness analysis typically looks for the probability that a region establishes an economic activity within the scope of eco-innovation as a function of related activities in that place.

Finally, we believe that EIs have the intrinsic characteristic of avoiding one of the main negative effects of innovations in general, one of the components of the “dark side of innovation” [79], namely, that of environmental degradation. Indeed, from the Industrial Revolution to the present day, many innovations have contributed to the environmental changes that are currently threatening the planet through pollution, loss of biodiversity, climate change, etc. Therefore, in view of a necessary and urgent sustainable global development, EIs are essential in all productive activities.

Supplementary Materials: The following are available online at <https://www.mdpi.com/article/10.3390/su13148065/s1>, Figure S1: Drivers of eco-innovation on eco-innovative companies, by sectors of the extractive and manufacturing industries, Brazil, 2015–2017; and Figure S2: Impacts of eco-innovation on eco-innovative companies, by sectors of the extractive and manufacturing industries, Brazil, 2015–2017.

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Appendix A

List of variables from the correlation analysis.

1. Innovation rate
2. Innovative intensity rate
3. Innovative intensity rate R&D internal
4. Product innovation rate—national market
5. Product innovation rate—world market
6. Process innovation rate—national market
7. Process innovation rate—world market
8. Main responsible product innovation—the company
9. Main responsible product innovation—another company in the same group
10. Main responsible product innovation—in cooperation with another company
11. Main responsible product innovation—another company and institute
12. Main responsible process innovation—the company
13. Main responsible process innovation—another company in the same group
14. Main responsible process innovation—in cooperation with another company
15. Main responsible process innovation—another company and institute
16. Number of workers exclusively dedicated to R&D
17. Number of researchers in R&D activities
18. Number of graduate workers in R&D activities
19. Number of undergraduate workers in R&D activities
20. Expenditure on innovative activities—internal R&D activities
21. Expenditure on innovative activities—external R&D activities
22. Expenditure on innovative activities—external knowledge
23. Expenditure on innovative activities—software
24. Expenditure on innovative activities—machinery and equipment
25. Expenditure on innovative activities—training
26. Expenditure on innovative activities—market innovation
27. Expenditure on innovative activities—industrial and other projects
28. Innovative activities—Internal R&D (high or medium relevance)
29. Innovative activities—external acquisition of R&D *
30. Innovative activities—acquisition of another knowledge *
31. Innovative activities—acquisition of software *
32. Innovative activities—acquisition of machinery and equipment *
33. Innovative activities—training *

34. Innovative activities—introduction of new technical innovations *
35. Innovative activities—industrial design and other techniques *
36. Benefits of innovation—improving the quality of goods and services *
37. Benefits of innovation—expansion of the range of goods and services *
38. Benefits of innovation—maintenance of market share *
39. Benefits of innovation—expansion of market share *
40. Benefits of innovation—opening new markets *
41. Benefits of innovation—increase in productive capacity *
42. Benefits of innovation—increased production flexibility *
43. Benefits of innovation—reduction of production costs *
44. Benefits of innovation—reduced labor costs *
45. Benefits of innovation—reduction of raw material consumption *
46. Benefits of innovation—reduction of energy consumption *
47. Benefits of innovation—reduction of water consumption *
48. Benefits of innovation—expansion of the control of aspects related to health and safety *
49. Benefits of innovation—compliance with standard regulations and standards *
50. Barriers of innovation—excessive economic risks *
51. Barriers of innovation—high costs of innovation *
52. Barriers of innovation—lack of adequate sources of financing *
53. Barriers of innovation—organizational rigidity *
54. Barriers of innovation—lack of qualified personnel *
55. Barriers of innovation—lack of information about technology *
56. Barriers of innovation—lack of market information *
57. Barriers of innovation—difficulty adapting to standards, rules and regulations *
58. Barriers of innovation—scarcity of adequate external technical services *
59. Barriers of innovation—centralization of innovation activity in another group company *
60. Barriers of innovation—few possibilities for cooperation with other companies/ institutions *
61. Barriers of innovation—weak consumer response to new products *
62. Information sources—R&D Department *
63. Information sources—other areas in the company *
64. Information sources—another company in the group *
65. Information sources—suppliers *
66. Information sources—customers or consumers *
67. Information sources—competitors *
68. Information sources—independent consultants and consultants *
69. Information sources—universities or other higher education centers *
70. Information sources—research institutes or technology centers *
71. Information sources—professional training centers and technical assistance *
72. Information sources—testing, assay and certification institutions *
73. Information sources—conferences, meetings and specialized publications *
74. Information sources—trade fairs and exhibitions *
75. Information sources—computerized information networks *
76. Cooperation—customers and consumers *
77. Cooperation—suppliers *
78. Cooperation—competitors *
79. Cooperation—another company in the group *
80. Cooperation—consultancy firms *
81. Cooperation—universities and research institutes *
82. Cooperation—professional training centers and technical assistance *
83. Cooperation—testing, testing and certification institutions *
84. Organizational Innovation—management technique

85. Organizational Innovation—environmental management technique
 86. Organizational Innovation—work organization
 87. Organizational Innovation—external relations
 88. Marketing Innovation—concepts/strategies
 89. Marketing Innovation—aesthetics, design and others
 90. ECO-innovators that publish Sustainability Reports
 91. ECO-innovators that produced renewable energy
- * high or medium relevance.

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Article

The Impact of Succession Management on Small and Medium Enterprises' Sustainability in Lagos State, Nigeria

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Abstract: This study investigated the impact of succession management on small and medium enterprises' (SMEs) sustainability in Lagos, Nigeria. The study adopted a descriptive survey research method and its participants were selected from five SMEs across Lagos State, based on their number of years of operating, staff strength, and branch locations. The enterprises included Gnakk Enterprises, Dreamville School, Vitus Cosmetics, Osi Ventures, and Chijioko Frozen Foods. The Pearson product moment correlation coefficient was used to analyze the hypotheses, which revealed that succession management had a positive correlation ($r = 0.934$, p -value < 0.05) with corporate sustainability amongst SMEs in Lagos State, Nigeria. Hence, the study concluded that in respect of strategic recruitment, succession management attracts and assists to retain a high performing skilled labour force.

Keywords: capability; leadership; organization; survival; workforce

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1. Introduction and Theoretical Background

The present economic climate regards businesses as the most important driver of national economic development and growth. Organizations compete to gain and maintain a competitive edge over rivals. To preserve an optimum level of corporate performance, a variety of resources are employed, including finances, workforce, and machinery [1,2]. However, amongst these resources, human resources (workforce) is the most critical in any organization [3,4]. Currently, many organizations, especially small and medium enterprises (SMEs), expend significant energy trying to attract customers, while they spend much less time on the workforce to retain these customers. Almost all organizations work hard to attain corporate sustainability [5,6]. However, there seems to be a significant gap between what they wish to attain and what they eventually receive [7]. Finding a long-term solution to the situation and sustaining a competent workforce to deliver corporate sustainability, remains a challenging aspect and process for firms, as it requires effective strategic and succession management. Dauda [8] and Mohrman and Lawler [9] claim that succession management enables SMEs to identify a high potential workforce and talented prospects that possess leadership capabilities and business acumen, which are required to execute long term strategic business plans, while the way in which business executives respond to succession could influence corporate sustainability [10,11].

Bansal and Song [12] argue that the term corporate sustainability is both current and provides a foundation for empiricism. The authors point out that corporate sustainability's early emphasis was on society and social issues, which were portrayed as obligations to interested parties at that time. Contrarily, they mention that early corporate sustainability

focused on environmental management, which is distinct from the environmental protection debate that currently surrounds economic development, now known as sustainable development [13,14]. Furthermore, they emphasize that the corporation is nested in social and environmental systems while discussing corporate sustainability. From a nomothetic standpoint, Bansal and Song [12] also argue that the terms corporate and sustainability have different antecedents and results, rendering their current homogeneity a challenge. They also state that the introduction of strategic approaches to the problem of corporate sustainability and the environment resulted in their confluence. It generates strategic options that are more easily aligned with the dominant neo-classical conception of SMEs as a profit-driven business.

In Nigeria, particularly in Lagos State, SMEs are currently experiencing prolonged volatility as a result of a high incidence of staff turnover, nepotism, corrupt practices, and inconsistent succession management [3,15]. These have become worrisome, especially owing to the nation's current economic and financial recession. As ineffective, inconsistent, and skewed succession planning continues to infect and saturate every part of their business, the impacts of this on SMEs remain unresolved and unacceptable. Hence, it has had a significant impact on their overall performance, as well as on the morbidity of several. Collings and Mellahi [16] claim that succession management has thus far been premised on the idea of a declining workforce base, whilst owing to the present economic situation, SMEs now understand that to gain and maintain a competitive edge, they must manage their workforce effectively. To do this, they must confront the realities of global succession management (GSM) and its several challenges, while developing human capital management activities to meet those challenges [17,18]. Hence, this enquiry, which investigates the impact of succession management on SMEs' sustainability in Lagos State, Nigeria, is justified.

1.1. The Resource-Based View (RBV)

Although others have contributed to development of the resource-based view of strategy, Wernerfelt is credited with coining the term as we know it today [19–21]. The said author opines that a corporation is a collection of resources that is tethered to it semi-permanently [22]. A firm's RBV comprises the resources that it has created to make it viable within the sector, whilst emphasizing its internal environment as a driver of competitive edge. Since the 1980s, research focus has switched from industry structure, including the five forces model and the structure–conduct–performance (SCP) paradigm to the firm's internal structure, comprising both resources and experiences (as the key components of the RBV). The RBV also uncovered that an enterprise's resources, which it owns, deploys, and uses, are significantly more important than industry structure [21,23].

Only the most strategic and valuable resources and competencies should be considered as competitive advantage sources, according to scholars who subscribe to the RBV [21,24–26], and who have used terms such as core competencies. Competitors cannot reproduce, substitute, or recreate core competencies, which are unique, scarce, and highly valued firm-based resources. Huang [26] posits that there is a distinction between tangible and intangible resources, with intangible resources being the most essential in terms of strategy. They believe that intangible assets are more likely to be used to create a long-term competitive edge than material resources. The RBV combines the two variables (succession planning and corporate sustainability) by offering insight into a firm's resources, competencies, and strategies, as well as how these might be utilized for a better, more sustainable and long-lasting business.

1.2. Research Question

The above background triggered the research question presented below.

1. To what extent does succession management impact SMEs' sustainability in Lagos State, Nigeria?

1.3. Research Objective

The objective of the study is stated below.

1. To investigate the impact of succession management on SMEs' sustainability in Lagos State, Nigeria.

2. Literature Review

2.1. Succession Management

The concept of succession management refers to the process that business owners im-
plore to attract, evaluate, and strengthen their workforce to guarantee that they are capable
of playing important roles in the firm [27,28]. It is the process of finding and evaluating
potential successors, whilst preparing them for present and future employment prospects
in the company. In addition, succession planning necessitates identifying successors and
engaging key personnel in the firm to guarantee their involvement and commitment on
a long-term basis [8]. Succession planning is a dynamic, continuing process of identify-
ing, evaluating, and developing leadership candidates for the future. It is also used to
evaluate, develop, and recognize key contributors who can satisfy future strategic and
operational requirements.

Ahsan [28] asserts that succession management is a way of determining vital staff
potential and having a backup strategy for their smooth replacements. There is a constant
suspicion or anxiety in the minds of SMEs' management concerning a shortage of future
successors for replacements at all administrative levels [5,15]. This creates a lacuna that
mitigates continuity of business operations, viability and sustainability, which introduces
the need for an established succession management system and structure in the enterprise.
Preparedness for an unexpected shortage in an enterprise's workforce base and corpo-
rate sustainability signals the importance of succession management, which is a creative
strategy and means to build competence, career advancement, and staff promotion [7,8].
As a strategy, succession management should be majorly considered in these aspects,
including equipping the workforce with pre-requisite knowledge and capability for the
new task. The successor's effective training and development demands follow and, finally,
management accepting the successor. Rothwell [29] asserts that if succession management
is optimally and effectively executed, it will enable the corporation's sustainability and
will ensure fulfilment of the workforce's aspirations. The author maintains that steps or
efforts are engineered for succession management to have a positively significant impact
on managerial operations, if well integrated [30,31].

2.2. Strategy for Succession Management

A thorough succession management strategy includes several actions that serve as a
road map to create succession plans. Ioannou and Serafeim [30] and Dauda [8] aver that
there is no such thing as a one-size-fits-all solution for succession planning; hence, different
organizations will use diverse components of any succession planning strategy. To begin,
critical jobs must be assessed in terms of the skills and experience that leadership roles
require. Then, based on management's assessments of their performance and potential for
advancement, they should identify notable talent at the company's top two or three levels.
Secondly, through formal education, leadership and management training, coaching or
mentoring, and job improvement, management should analyze key talents, the primary
development needs of skills suited for the next level, and strategies for future successors.
Finally, an annual assessment should be used to track the employee development plan's
implementation, as well as adoption of a transition strategy to select leaders from the talent
pool to fill vacancies. Internal capabilities, talent pool planning, and future succession and
replacement training are the three types of succession planning that are commonly used in
this respect [27,29].

2.3. Models of Succession Management

A succession management model is a framework, structure or roadmap that depicts the integral aspects of a viable, unbiased, and successful identification, development, and retention of high performers [28,31]. Corporations typically use one of three succession management models, as shown below:

1. Emergency substitutions or short-term planning;
2. Long-term talent management or planning; and
3. A mix of the above-mentioned strategies.

In the first model emergency or short-term planning substitutes are the most typical succession management, while they are also a crucial point for all kinds of firms. This strategy focuses on an immediate need, such as the need to replace personnel who leave the company. Second, the long-term personnel management or planning model is built on a strategic framework for a company's future goals, key occupations needed for development, and the ideal people to perform those jobs. Some companies seek the participation of all employees in the required evaluation process, which helps them to find the best candidate to train for the company's future needs [27,29]. If a firm intends to nurture its leadership from within its existing talent pool, succession planning becomes a critical component of its long-term human capital strategy. Specialized personnel or a talent pool, identifying and expanding future talents that are vital to the enterprise's performance, and engaging and retaining people through engagement in an internal capacity, are all advantages of this method. Finally, the mixed model combines the first and second plans by allowing senior management to plan for the company's long-term growth and its personnel, while also preparing to guarantee that their corporate activities are not disrupted by emergency replacements or are not hampered by the loss and scarcity of qualified individuals [8,29]. The benefits of succession management are discussed next.

2.4. Benefits of Succession Management

Regardless of the ownership structure, succession management is crucial for a company's long-term viability and competitive advantage. Hence, succession management aids a company's deliberate approach to develop leaders and staff competence evaluation. It is extremely important when a government regulation forces mass retirements to keep a company's critical knowledge base intact [8]. According to Huang [26], succession management allows employee movement within the company. This has the potential to promote employee confidence. Rothwell [29] notes that succession planning is a talent management technique that is essential to attract, maintain, and advance specific capabilities that help a company remain competitive. Internal resourcing, reducing personnel turnover caused by high-fliers who change jobs frequently, and preparing suitable candidates for top management roles, are all seen to benefit from succession management [26].

Dauda [8] reiterates that consistent succession management provides broader insight into not only focusing on switching top officials, but also forces firms to examine all staff for the enterprise's future. The main benefit of succession planning is the proactive construction of a strong future staff resource base, which is critical to attract and retain the best and most important people who will contribute to the company's current and future growth. Hence, suitable employees with pre-requisite expertise in specific jobs doing specific duties, is critical for corporate sustainability [8,26,32].

2.5. Corporate Sustainability

The ability of a company to persist is referred to as corporate sustainability [20,33,34]. Sustainability is defined as long-term company success that also assists with advancing the economy and society in terms of promoting a stable society and a healthy environment. It concerns contributing constructively to society, while also safeguarding the company's operations and the communities in which it operates [3,35]. The three pillars of business sustainability that have been identified are environmental, socio-cultural, and economic sustainability. The use of resources to meet human, economic, social, and environmental

demands in a way that respects the interests of current and future generations, is known as sustainable development [26,36], which is discussed next.

In essence, corporate sustainability is the belief that businesses and their directors have a responsibility that extends beyond profit [33]. Dyllick and Hockert's [36] widely accepted definition of business sustainability is helpful to understand its current usage. The authors describe business sustainability as a company's ability to meet the needs of its immediate stakeholders without jeopardizing its potential to meet the needs of future stakeholders. This explanation's scope, which is clearly borrowed from sustainable development, is restricted to the organization. The company's stakeholders, or those who have direct control over its operations, finances, or market, are a source of concern. There is no mention of ethics in the definition. Although others, such as Hahn and Figge [33], aver that there appears to be some implicit pragmatic consensus that corporate sustainability refers to a composite and multi-faceted construct that includes environmental, social, and economic organizational outcomes, there is no explicit mention of the environment. It is also worth noting that the sustainability's intergenerational aspect is confined to the next set of stakeholders. Hence, within a finance context, it has a fundamental and organizationally focused idea [32].

Amini and Bienstock [34] attempted to synthesize and operationalize the debate recently. They validate the term corporate sustainability as being organizationally particular in terms of scope and its principal purpose as being ecological in their well-developed work, which recognizes the complexity and far-reaching features of sustainability. While Vermeulen and Witjes [37] include innovation as a new dimension, the policy goal is corporate sustainability's strategic profit potential. Finally, they propose a slightly different interpretation of the term, claiming that it refers to particular organizations implementing plans to attain long-term sustainability [37,38].

2.6. Sustainable Development Practices

The commerce industry in Lagos State, Nigeria, was selected for this study owing to reports of their involvement in sustainable development, as published in the National Bureau of Statistics [37,39]. The data reviews reported by the National Bureau of Statistics show the following common sustainability practices amongst SMEs.

Waste reduction and recycling: Staff are encouraged to use online approvals, electronic communications, and other web-based programs rather than printing documents, except when necessary [20,40]. For certain types of transactions, online business transactions have replaced cash and cheque books in SMEs, which has resulted in significant paper savings and the transmission of electronic transactional documents.

Diversity: The organizations attract high-flying employees by promoting a diverse workforce and by treating all employees equally and without discrimination on the basis of gender, ethnicity, color, nationality, religious beliefs, or any other distinguishing trait, whilst ensuring that under-represented groups continue to have access to open positions within the organization.

Community investment projects: The SMEs invest in the communities in which they operate by providing basic social services, such as clinic rehabilitation, school renovation, re-equipment of craft workshops, book donations for school libraries, and science laboratory construction, as well as by increasing long-term employment through a community service effort inside the company [12,39,41].

3. Empirical Review

Akinyele et al. [27] considered the impact of succession planning on business persistence. According to empirical research from Covenant University, the study's purpose was to investigate the impact of succession planning on organizational persistence. A survey and an individual interview were utilized to gather the required data for the investigation. Pearson's correlation coefficient was used to test the hypotheses. The findings showed that succession planning significantly affects organizational survival. This reveals techniques

for sharing institutional information and retaining institutional data and, accordingly, guaranteeing the firm's presence. The study likewise uncovers that career advancement largely affects Covenant University's organizational longevity. Thus, proficiency amongst staff is a requirement for them to advance towards addressing the university's succession requirements, which then guarantees the institution's long-termed survival.

Maguta [42] examined the impact of succession planning techniques on the daily operations of non-governmental organizations (NGOs) in Kenya, investigating the link between succession planning approaches and attrition rates, organizational friction, and shareholder expectations. A descriptive strategy geared towards Nairobi-based registered NGOs was ideal for the study. The study gathered both qualitative and quantitative data from 15 non-governmental groups, and presented its findings, using illustrative frequency distributions. Finally, the study found that succession planning is a continuous worry for NGOs seeking to maintain their performance. In Nairobi, there was a gap between the traditional management of non-governmental organizations and implementation of succession planning approaches. Maintaining relevance, as well as strengthening other successful managerial talents, also proved to be a key contributor towards NGOs' long-term success.

Syeda and Abida [43] studied the succession planning impact on employee commitment in the telecommunications industry. For scholars in the field, the study provided an overview of the industry's succession planning impact on employee commitment, focusing on the role of talent management in the contemporary global economy. Only 250 copies of the questionnaire were returned after being personally distributed at the head offices and franchises of five different telecommunication companies in Rawalpindi, Islamabad, for the purpose proposed. The statistics were examined, using SPSS (Statistical Procedures for Social Sciences). The study's findings revealed that employee commitment and effective succession planning have a significant relationship. This result centres on successful succession planning assisting with developing successful leadership and their role as the most crucial enabler of both workplace and employee engagement, as well as work teams, particularly in the telecommunications industry, at large.

Hanaysha [44] considered staff productivity to be one of the key management themes that have received significant scholarly attention and is thought to be a vital mechanism for advancing business sustainability. To ensure long-term success, it was also necessary to have a fundamental awareness of the basic components that drove sustainability. To achieve the purpose, primary data was collected, using an online survey, where a sample of 242 staff from public universities in Northern Malaysia were polled. Structural equation modeling was used to analyze the data, which showed that work engagement has an affirmative impact on staff productivity. Furthermore, the research shows that all aspects of work engagement such as enthusiasm, dedication, and engagement, have a significant impact on employee outcomes.

3.1. Research Hypothesis

From the above literature review and theoretical foundation, the following null and alternate hypotheses were formulated:

Hypotheses 1: *Succession management does not relate positively to corporate sustainability.*

Hypotheses 2: *Succession management relates positively to corporate sustainability.*

3.2. Knowledge Gaps

The literature shows a lack, dearth, and paucity of local material and studies on how small and medium businesses in Lagos State, Nigeria, can achieve a competitive edge by implementing consistent succession management that propels their sustainability and expansion of operations, both nationally and globally.

4. Research Methodology

The research adopted a descriptive survey method. The total number of SMEs in Lagos has been quoted as 3,224,324 [15]; however, only those who fulfilled the selection criteria were selected for this study. The selection criteria were based on their number of years in operation, capital base, and branches across Lagos State. Five SMEs were selected randomly, and these included Gnakk Enterprises, Dreamville School, Vitus Cosmetics, Osi Ventures, and Chijioke Frozen Foods. The research participants were staff at the selected SMEs, comprising a total of 3126 staff from the five (5) SMEs. A sample size of 359 was received, using the Bill Godden formula. Based on the population being finite, a proportionate stratified sampling approach, using Bowley's proportional formula, was used to choose respondents in each of the selected firms under investigation. The questionnaire was designed, using the 5-point Likert scale and was administered manually to respondents. Content validity of the instrument was conducted by three management experts from both the industry and academia. The instrument's reliability was tested using Cronbach alpha, which yielded a coefficient of 0.83, suggesting strong instrument consistency, and at a 5% probability threshold of significance. Lastly, the study used the Pearson's product-moment correlation to analyze the data.

5. Data Analysis and Results

5.1. Results

Table 1 indicates that a total of 359 questionnaires were distributed: 54 were distributed to Gnakk Enterprises (7 administrative staff and 47 low-cadre staff) and 46 were returned; 125 questionnaires were distributed to Dreamville School (10 to administrative staff and 115 to low-cadre staff) and 100 were returned; 103 were distributed to Vitus Cosmetics (6 to administrative staff and 97 to low-cadre staff) and 93 were returned; 48 were distributed to Osi Ventures (7 to administrative staff and 41 to low-cadre staff) and 29 were returned; and 54 were distributed to Chijioke Frozen Foods (5 to administrative staff and 24 to low-cadre staff) and 23 were returned.

Table 1. Questionnaire distribution and return.

Organizations	Distributed Number		Returned Number		Number Not Returned	
	Administrative Staff	Low-Cadre Staff	Administrative Staff	Low-Cadre Staff	Administrative Staff	Low-Cadre Staff
Gnakk Enterprises	7	47	4	42	3	5
Dreamville School	10	115	8	92	2	23
Vitus Cosmetics	6	97	5	88	1	9
Osi Ventures	7	41	6	39	1	2
Chijioke Frozen Foods	5	24	3	20	2	4
Total	35	324	26	281	9	43
Grand Total		359		307		52

Source: Field Survey, 2021.

5.2. Descriptive Statistics Related to the Research Objective

Table 2 indicates that 46 of the respondents (15%) strongly agreed, 91 (30%) agreed, 32 (10%) were undecided, 97 (32%) strongly disagreed, and 41 (13%) strongly disagreed with the assertion that attracting and retaining high-performing employees is crucial for an organization's success.

Table 3 shows that 76 (25%) of the 307 respondents strongly agreed, 146 (48%) agreed, 22 (7%) were undecided, 16 (5%) strongly disagreed, and 47 (15%) disagreed with the premise that strategic recruitment has a significant bearing on firm survival.

Table 2. It is vital for an organization's success to attract and retain high-performing employees.

	Gnakk Enterprises		Dreamville School		Vitus Cosmetics		Osi Ventures		Chijioko Frozen Foods		Total	Percentages (%)
	Admin. Staff	L-C. Staff	Admin. Staff	L-C. Staff	Admin. Staff	L-C. Staff	Admin. Staff	L-C. Staff	Admin. Staff	L-C. Staff		
SA	2	10	3	52	2	15	1	9	-	18	46	15
A	2	12	1	15	2	43	2	15	2	2	91	29.6
UD	-	5	3	5	-	10	1	3	-	-	32	10.4
SD	-	4	1	5	-	-	2	10	1	-	97	31.6
D	-	11	-	15	1	20	-	2	-	-	41	13.4
Total	4	42	8	92	5	88	6	39	3	20	307	100

Source: Field Survey, 2021. Where: SA—Strongly agree; A—Agree; UD—Undecided; SD—Strongly disagree; D—Disagree.

Table 3. Strategic recruitment significantly affects firm survival.

	Gnakk Enterprises		Dreamville School		Vitus Cosmetics		Osi Ventures		Chijioko Frozen Foods		Total	Percentages (%)
	Admin. Staff	L-C. Staff	Admin. Staff	L-C. Staff	Admin. Staff	L-C. Staff	Admin. Staff	L-C. Staff	Admin. Staff	L-C. Staff		
SA	2	10	3	20	1	18	5	15	-	2	76	24.8
A	2	10	4	30	3	60	-	19	3	15	146	47.6
UD	-	5	-	10	1	5	-	-	-	1	22	7.2
SD	-	2	-	12	-	-	-	-	-	1	16	5.2
D	-	15	1	20	-	5	1	5	-	-	47	15.3
Total	4	42	8	92	5	88	6	39	3	20	307	100

Source: Field Survey, 2021. Where: SA—Strongly agree; A—Agree; UD—Undecided; SD—Strongly disagree; D—Disagree.

Table 4 displays the descriptive statistics for succession management and its relationship with corporate sustainability. Corporate sustainability received a mean response rate of 2.9 with a standard deviation of 1.7, while succession management received a mean response rate of 3.3 with a standard deviation of 1.5. Based on standard deviation values of 1.7 and 1.5, it may be deduced that the dependent and independent variables have almost the same variability of data points. Hence, succession management is a larger part of the equation when it comes to factors that affect a company's long-term viability.

Table 4. Descriptive statistics.

	Mean	Std. Deviation	N
Corporate sustainability	2.9348	1.71791	307
Succession management	3.2600	1.47450	307

The Pearson correlation coefficient result shows the link between succession management and long-term corporate sustainability. Table 5 above shows the number of cases, the correlation coefficient, and the significant values. The correlation value of 0.934, indicates that the association is significant at a 0.05 level (2-tailed) and demonstrates a high positive link ($r = 0.934$, p -value = 0.000) between succession management and corporate sustainability. Hence, the null hypothesis is rejected and the alternate hypothesis that succession management relates positively to corporate sustainability, is accepted.

Table 5. Correlations.

		Corporate Sustainability	Succession Management
Corporate sustainability	Pearson's Correlation	1	0.934 **
	Sig. (2-tailed)		0.000
	N	307	307
Succession management	Pearson's Correlation	0.934 **	1
	Sig. (2-tailed)	0.000	
	N	307	307

** at the 0.05 level, the correlation is significant (2-tailed).

6. Discussion

The findings relate to determining how succession management influences the corporate sustainability of small and medium enterprises (SMEs) in Lagos State, Nigeria. The study's hypotheses were tested using the Pearson product moment correlation coefficient, which indicated that succession management is associated with corporate sustainability of SMEs in Lagos State, Nigeria ($r = 0.934$, p -value < 0.05). The stated result and statistical figures show that every succession management strategy conducted or practiced in SMEs follows with the enterprise's sustainability. These research findings support Syeda and Abida's [43] investigation, which offers a link between efficient succession planning and employee satisfaction exists ($F(1, 43) = 24.070$, $p 0.001$), positive succession planning supports effective leadership, and leadership is the most significant enabler of employee engagement on the job, in the business, and at work. Akinyele et al. [27] found that succession planning had a significant impact on organizational survival in a study that observed the stated variables. While based on Toliver's [45] findings, managers established and maintained a leadership position for high-potential individuals in imminent management roles by tracking in-house personnel with fundamental leadership abilities, re-engineering the in-house succession pipeline, and establishing replacement design mechanisms. Furthermore, this study's findings concur with Maguta [42], who asserts that succession planning, which involves retaining employees and managing organizational problems, is essential, and that meeting shareholder expectations has a positive relationship with an NGO's performance ($r = 0.743$, $r = 0.641$, and $r = 0.866$). In addition, it proffers that succession planning reduces employee turnover rates by enhancing staff retention, which influences NGOs' performance and sustainability. This study's result aligns with findings from oral interviews that: succession management helps SMEs to reduce the potential for costly errors by incentivizing employees to invest in firm-specific human capital roles to meet future needs, strengthens the internal leadership bench, minimizes potential negative effects that it may cause, supports diversity in the enterprise, and accelerates development.

However, the outcomes of this investigation contradict the findings of Garg and Weeie [46] who posited that in small and micro enterprises investigated in Johannesburg, South Africa, there was a disconnect between how succession development was viewed and how it actually worked, stressing that these small and micro enterprises did not have established procedures to groom, train, and generate qualified successors.

6.1. Contribution of the Study to the Body of Knowledge

This study focuses on succession management and corporate sustainability, assessing its impact on SMEs in Lagos State, Nigeria. In line with the call for research and the paucity in scholarly investigations on the construct variables (succession management and corporate sustainability), sector (small and medium enterprises) and geographical scope of the study (Lagos State, Nigeria), this research establishes a theoretical foundation and empirical evidence for a link between succession management and corporate sustainability in SME's, particularly in the current economic downturn.

6.2. Limitations of the Study

There was a paucity of research materials on the subject matter under investigation, coupled with an unwilling attitude among respondents. However, this was curbed by sourcing relevant related literature online to buttress the discourse, while regular meetings were held with respondents to elicit their feedback relating to the research.

7. Conclusions

Succession management is arguably human capital development's brainbox and has been at the heart of corporate sustainability. Hence, in a fast-paced business environment, succession planning makes it easier to integrate all systems and make well-informed decisions regarding new or familiar changes in company and workforce management. During the period of this present economic recession, the small and medium enterprises (SMEs)

under study, namely Gnakk Enterprises, Dreamville School, Vitus Cosmetics, Osi Ventures, and Chijoke Frozen Foods have expanded in every facet of their operations, either in terms of market share or customer patronage, thereby advancing their productivity. Thus, this study concludes that succession management, in respect of strategic recruitment, attraction, and retention of high-performing staff, is a pivotal strategy that delivers corporate sustainability. This is a consequence of the study's population responses who are stakeholders of the SMEs in Lagos State, Nigeria, as they agreed and strongly agreed with the research data that formed the basis for inference making and result generalization. Hence, SMEs should adopt succession management that is proper, efficient, and consistent by proactively ascertaining, evaluating, and implementing succession plans and training employees to take on or succeed in critical leadership positions, as this ensures the company's longevity and sustainability in any business environment.

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Data Availability Statement: Primary data was used for the study which was provided by persons in the study. As such, there are no links to publicly archived datasets analyzed or generated during the study.

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Article

The Influencing Factors on Impulse Buying Behavior of Consumers under the Mode of Hunger Marketing in Live Commerce

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Abstract: The sustainability of live commerce is closely dependent on the impulse buying behavior of consumers because of its live characters compared to the traditional e-commerce mode. Hunger marketing is a widely adopted mode in live commerce, however, the influencing factors on impulse buying behavior of consumers under the mode of hunger marketing in live commerce is currently lacking. Here, based on SOR theory, we carefully studied how external stimulus variables (anchor characteristics, online comments, logistics service quality, promotion incentive information, and promotional time limit) affected consumers' impulse buying behavior under the inner mechanism reaction factors (perceived trust and perceived value). By collecting questionnaires from 533 Chinese online consumers, we processed these data using SPSS23.0 and analyzed them using the structural equation model (SEM) generated by AMOS 25.0. The results showed that extrinsic stimulus variables (except for the promotional time limit variable) have significant positive effects on impulse buying behavior through partial or total positive effects on intrinsic mechanisms. We analyzed the reasons for all these results in detail, and thought the reason that the promotional time limit did not have a significant impact on the perceived value might be due to the rapid increase in the frequency of live commerce. Moreover, we also put forward the suggestions on the basis of these influencing factors to improve the sustainable development of live commerce.

Keywords: live commerce; hunger marketing; perceived trust; perceived value; impulse buying behavior

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1. Introduction

The sustainable development of e-commerce requires enterprises to innovate marketing forms and models constantly. There are many problems in the traditional retail industry, such as high cost, low realizable profit, a poor precipitation effect and a small radiation range. With the rapid development of network technology and mobile terminals in recent years, the mode of live commerce provides new opportunities for the sustainable and healthy development of e-commerce. Live commerce is a new type of social interaction platform that provides a way to promote sustainable product consumption online [1]. It breaks through the limitations of time and space, and creates a refined live commerce marketing system of "private sphere + retail + full scene" for consumers [2]. This model combines a stereo environment, preferential price, diversified products, fast payment methods, convenient logistics services and other aspects, giving consumers a strong sense of presence, and stimulating consumers' purchase intention, thus driving product sales and obtaining rich profits. 2016 was the first "Year of Live Commerce" in China [3]. The ability of e-commerce platforms to cash in goods has been truly realized since the rise of the "Double 11" online shopping festival in 2017. Since the outbreak of the epidemic in 2020, offline consumer demand has been suppressed, making the facilitating role of online live streaming of goods more obvious. How to maintain the sustainable development of live commerce is a problem that should be paid attention to at present, and this requires the common attention of both industry practitioners and academia.

It can be said that live commerce as an emerging business model not only brings huge profits but also attracts a large amount of user traffic. Although it is difficult to find a replacement in a short period of time, live commerce has also encountered some shortcomings while prospering. Its sustainable development has become the focus of attention from all walks of life, and only a profound analysis of the problems aimed at developing a sound operation mechanism that plans the right direction of development will help with these issues. Live commerce has a high acceptance among contemporary consumer groups, so research based on the perspective of users is more conducive to revealing the industry's shortcomings, helping it break through the bottleneck period and achieve long-term sustainable development.

In order to maintain the sustainable development of e-commerce live commerce, it has become a hot topic to study the purchasing behavior of consumers. Through situational experiments and relevant secondary data, Huang et al. found that the recommendation of hedonic products by reputable anchors can help trigger the recognition mechanism of consumers and improve their purchase intention and product sales [4]. Yan et al., (2021) believed that the popularity of anchors, interactivity and personalized service in live commerce had a positive impact on consumers' purchasing behavior to varying degrees [5]. In this process, consumers' perceived value plays a mediating role between the characteristics of live commerce and purchasing behavior. Liu et al., (2013) proved that commodity availability and website ease of use in online shopping features significantly affect consumers' visual attractiveness, which in turn produces instant satisfaction and influences consumers' impulse buying [6]. Zheng (2021) found in his research that the higher the degree of interaction with users in the broadcast room, the more likely users will have flow experience and the more likely they will form cross-purchase intention [7].

Previous research has shown that different marketing models can lead to different purchasing behaviors of consumers. In the traditional marketing mode, consumers' purchasing behavior is attracted by advertising marketing, direct marketing, and other strategies [8]. For live commerce, there are also various types of goods. For example, in the traditional e-commerce marketing model, some brands simply introduce their products for the purpose of doing so. Specifically, the anchors show, explain and try on the products in a full range in the form of live commerce so as to deepen consumers' understanding of the products and brands. However, there are no preferential activities. In this single mode, it is difficult to arouse consumers' shopping intentions. In addition, when e-retailers adopt the influence of marketing incentives, situational influence and individual characteristics, live commerce is more likely to trigger consumers' impulsive buying behavior [9]. It can be seen that under different sales modes, consumers' purchasing behaviors are very different, so it is more accurate to study the purchasing behaviors under specific modes.

Currently, the single live commerce mode has gradually entered a soft state. In order to break through the sales bottleneck, "hunger marketing" has become a common marketing mode in live commerce. The "hunger marketing" strategy comes from the "utility theory" in economic theory, through making consumers feel satisfied [10] in order to build a solid psychological foundation for marketing. Hunger marketing strategy, in the final analysis, is a kind of aggregation promotion, mainly manifested as the combination of artificially low price control and supply restriction [11]. In live commerce, businesses rely on the platform's flow base to create a tense atmosphere and artificial phenomenon of short supply, which runs through three stages: early warm-up, middle empathy and late feedback [12]. For e-retailers, adopting the hunger marketing model can bring many advantages. First, by controlling retail price and total sales volume, the total profit of the supply chain is increased and the double marginalization effect is aggravated. Yu and Zhang (2018) studied the impact of the hunger marketing strategy on supply chain pricing, and coordinated the supply chain through a two-period pricing model [13]. Tolety (2016) studied hunger marketing, time-limited sales and cost optimization strategies of Xiaomi [14]. Chen (2016) studied the application analysis of hunger marketing in the mobile phone industry [15]. However, as a new strategy of live commerce, there are few studies on hunger marketing

strategy as the preset background. As a new development trend, it is more meaningful to study the impact of the hunger marketing strategy adopted by live commerce on consumers' purchasing behavior.

The buying behavior of consumers can be divided into purported buying and impulsive buying [16]. Intentional purchase refers to the planned purchase behavior of consumers. Impulse buying behavior tends to be unplanned but is carried out because consumers are aroused by positive emotions and have an immediate desire to have [17] a particular item. Wells and Veena (2011) defined impulse buying as the consumer being spontaneous and temporarily out of control, and having a strong desire to buy. Impulse buying behavior is very common [18]. Relevant (2018) studies show that modern consumers clearly pay attention to hedonism and realizable consumption styles [19]. Impulse buying accounts for about 80% of product sales, and the sales of new products are basically impulse purchases [20]. Jiang and Zhao (2013) found that the images of goods, services, convenience and safety have a significant impact on consumers' intentional purchases, and a virtual experience can stimulate consumers' impulsive purchase behavior [21]. Compared with offline shopping, online shopping consumers, as a result of time and space constraints, showed more obvious characteristics of impulse buying, especially with regard to the process of a live business platform. Businesses take advantage of these tendencies to motivate consumers to make impulsive buying decisions, and push them further into impulse buying behavior. In combination with the merchant hunger marketing model in live commerce, this article defines impulse buying behavior as the consumer's strong and eager purchase behavior under the stimulation of external factors on the premise of the absence of any clear purchasing plan on behalf of the consumer.

The hunger marketing model is often used in traditional marketing, but it rarely gets attention under the background of live commerce with goods. However, under the marketing environment of limited time and limit, most consumers are more likely to engage in impulsive consumption behavior. In addition, the existing studies adopt a relatively independent and decentralized approach, that is, they only study related factors separately, such as store environment [22], promotion intensity [23], time scarcity [24], consumer trust [25], etc. Few studies integrate these interrelated concepts. Taking SOR as the theoretical basis, we established a model and set the research background in the case of hunger marketing strategy in the mode of live commerce to comprehensively explore the influence factors of external stimulus factors and internal mechanism on consumers' impulsive buying behavior. This paper enriches the research field of consumer behavior in the context of e-commerce, provides precise supplement for consumers to make impulsive behavioral decisions in the online shopping environment, and helps e-commerce platforms and enterprises to change their innovation mode and realize sustainable development of e-commerce platforms.

This paper is divided into the following parts: The first part is the introduction. The second part proposes a theoretical model and hypothesis research. The third part is questionnaire design and data collection, and the fourth part tests and analyzes the collected data. The fifth part analyzes the hypotheses and conclusions. The sixth part puts forward accurate suggestions on the sustainable development strategy of hunger marketing under the current e-commerce model and points out the limitations of this paper.

2. Theoretical Basis and Hypothesis Research

2.1. Theoretical Basis of SOR

The SOR (stimuli-organism-response) theory is a cognitive theory of psychology that studies human behavior by adding the intermediate process of "individual psychological activity" on the basis of "stimulus-response" theory, emphasizing the mediating role of individual physiological and psychological activities. The SOR theory holds that the behavioral decision-making (i.e., response) whereby consumers decide to approach or avoid comes not only from the attention to external environmental factors (i.e., stimulation), but also from the sensory cognition of consumers' internal state (i.e., organism). The

SOR model is considered to be successful in explaining behavioral differences caused by various marketing stimuli and cognitive factors. The main advantage of the SOR model is that it is flexible and includes the opportunity to examine a variety of internal and external stimuli. The SOR theory is widely used to explain consumer behavior or consumer will, particularly based on the impact of external environmental characteristics on consumers' internal psychological state and behavioral response [26]. The SOR theory is widely used to explain consumer behavior or consumer will, especially based on the impact of external environmental characteristics on consumers' internal psychological state and behavioral response. Jing and Sung (2019) explored the effect of service recovery on customer behavioral intention in online shopping malls under the mediating effect of customer forgiveness based on the SOR model [27]. Hu et al., (2012) studied the influence of information content and information form on consumers' purchasing behavior under the mediation of channel mode through SOR theory [28].

Consumers' behavioral motivation is controlled by self-consciousness, and conscious cognition is the intermediary. When commodity browsers are stimulated by the external environment, they will rely on subjectivity to form a "cognitive structure". At this time, they do not act directly, but deliberately and actively obtain effective information from the stimulation process and consider whether to choose commodities, and then respond. "Stimulation" in the retail environment can often attract consumers' attention and cause changes in their psychological feelings. This stimulation is usually via external environmental factors, including marketing strategies and other objective effects; "Organism" is an individual's internal activity process. It is a cognitive process in which consumers consider themselves, their money and risk after receiving the information they see or hear; "Response" includes psychological and behavioral responses, that is, the decisions consumers will make after processing the information.

2.2. Research Assumptions

2.2.1. Research Assumptions of Anchor Characteristics

An e-commerce influencer is an important front in live commerce [29]. By virtue of a person's professionalism, popularity, interactivity and affinity, they interact with consumers in real time through live commerce platforms, serving as a bridge between businesses and consumers. Influencers help merchants to promote products and deliver product information and enhance their brand image. Meanwhile, as the executor of the hunger marketing strategy, e-commerce influencers help consumers to know more about products and stimulate consumer demand. Enthusiasm is based on the personality characteristics of the influencer, bringing consumers an enhanced shopping experience, and influencing their attitudes and bolstering the strength of the products they represent. They also enhance the scarcity of the product and add a sense of immediacy to the impending purchase. This is all designed to strengthen the perceived value of a product and guide consumers to make impulsive shopping decisions [30]. Zhang and Zhang (2021) pointed out that influencers play an important role in sales performance in network broadcasts, and categorized the characteristics of influencers into Internet celebrities' charm, entertainment and professional knowledge, confirming that these three characteristics have a positive impact on consumers' purchase intention [31]. Zhao and Wang (2021) divided influencer features into interactivity, authenticity, professionalism and popularity, and verified that influencer = characteristics had a positive impact on consumers' perceived trust and perceived value from four dimensions, thus promoting their purchase intention [32]. Based on this, the following hypotheses are proposed:

Hypotheses 1 (H1). *Anchor characteristics have a significant positive impact on consumers' perceived trust.*

Hypotheses 2 (H2). *Anchor characteristics have a significant positive impact on consumers' perceived value.*

2.2.2. Hypothetical Research on Online Comment Factors

As the carrier of information dissemination, online comments have attracted increasing attention from companies and consumers. The function of online comments not only reduces consumers' uncertainty about product quality and experience attributes [33], but also significantly affects the company's operational decisions and helps reshape business growth [34]. Combined with the characteristics of live commerce, this study defines online comments as real-time comments sent by consumers during live watching. The comments are displayed on the screen in the form of subtitles to each consumer who watches the live commerce, which provides help for the online interactions between businesses and consumers. It provides real-time answers to relevant information about products and services and creates a shared shopping experience. Online product reviews are a powerful source of information for consumers. Personal reviews help consumers reduce product uncertainty and imperfect product page information [35]. Online reviews provide consumers with the possibility of real quality on e-commerce platforms and play an important role in customer purchase decisions [36]. Qi (2021) built a research model for consumer acceptance of online comments based on the TAM model, which proved that the quantity and quality of online comments has a significant positive impact on purchase behavior [37]. Shen and Chang (2021) showed that online comments and customer experience are important factors affecting consumers' online purchase intentions [38]. Customer value plays an intermediary role in the relationship between them. Accordingly, the following assumptions are proposed:

Hypotheses 3 (H3). *Online comments have a significant positive impact on consumers' perceived trust.*

Hypotheses 4 (H4). *Online comments have a significant positive impact on consumers' perceived value.*

2.2.3. Hypothesis Research on Logistics Service Quality

Logistics services play an important role in the development of live commerce. It is not only the key link and basic guarantee of online shopping [39], but also the last link to complete the online transaction. Consumers are the direct service objects of logistics services. They not only pay attention to product quality and price, but also have a variety of logistics needs. Businesses need to integrate and optimize the allocation of resources in the market and improve the consumption experience to meet the personalized and differentiated logistics service needs of customers. Meeting the logistics service needs of consumers will help to improve the relationship quality between customers and businesses and enhance consumer satisfaction. Similarly, online shopping can enhance consumers perceived value by improving the quality of logistics services. When consumers have a pleasant shopping experience, the degree of perceived value will increase. There are concessions before sales and guarantees after sales, and consumers are more likely to have impulsive buying behaviors. Liang and Zhang (2016) believe that logistics services play an important positive role in consumers' psychological contract, and one of the key elements of this psychological contract is consumers' trust [40]. Liu (2021) used a regression model analysis method to verify that personalized logistics services can effectively enhance consumers' willingness to make repeat purchases under the intermediary influence of relationship quality [41]. At the same time, personalized logistics services also affect consumer satisfaction. In this process, consumer trust plays an intermediary role. Yan et al., (2020) divided the refined logistics service elements into reliability, responsiveness, timeliness and the attitude of distribution personnel, and verified the positive impact of the four elements on customer perceived value [42]. Accordingly, the following assumptions are proposed:

Hypotheses 5 (H5). *Logistics service quality has a significant positive impact on consumers' perceived trust.*

Hypotheses 6 (H6). *Logistics service quality has a significant positive impact on consumers' perceived value.*

2.2.4. Hypothesis Research on Promotion Incentive Information

Promotional incentive information is used by e-commerce enterprises to publicize promotional activities and introduce product information before and during live commerce, especially to highlight the preferential strength of a price discount [43]. E-commerce merchants attract users by influencing consumers' sensitivity to price [44] so as to improve consumers' participation and purchasing power. Especially in the hunger marketing mode under the e-commerce platform, in order to induce consumers to buy specific goods immediately, the promotion incentive is often stronger than daily purchase activities, which directly affects the perceived trust, value and purchase intention of price sensitive consumers. The promotional incentive information can make consumers perceive the temptation of the promotion to save money, the richness of promotion commodity categories, quantities and styles, and the interest of participating in rush buying activities in the broadcast room, so as to encourage public participation and consumption enthusiasm. Through this short-term stimulation tool, the broadcast room will form a shopping phenomenon of gathering shopping, which overcomes the wait-and-see mentality of consumers to a certain extent, strengthening consumers perceived trust with a rush buying atmosphere, thereby reducing perceived risks and eliminating pre-purchase doubts, and making impulse purchase decisions more likely. Prasilowati et al., (2021) believe that price promotion has a significant impact on customer satisfaction [45]. Chen (2021) pointed out that price promotion and gift promotion in promotion incentives can effectively improve consumers' perceived savings and reduce perceived risk, so as to enhance consumers' purchase intention [46]. Accordingly, the following assumptions are made:

Hypotheses 7 (H7). *Promotion incentive information has a significant positive impact on consumers' perceived trust.*

Hypotheses 8 (H8). *Promotion incentive information has a significant positive impact on consumers' perceived value.*

2.2.5. Hypothetical Research on Promotion Time Limit

As a marketing method, live commerce induces consumers to make immediate purchase decisions based on a certain amount of price discounts only available for a limited time. As one of the elements of the decision-making situation, time pressure plays a regulatory role in decision-making behavior [47]. In this short-term decision-making environment, under the atmosphere of exaggerating economic interests from businesses, consumers have a strong sense of time urgency, which affects consumers ability to obtain complete information and process the information in the process of evaluating the product. Instead, they pay more attention to the influencer's description of the items in question [48]. At the same time, shortened decision-making time leads to the impairment of consumers' cognitive functions, resulting in the perceived opportunity cost of "regret if you don't buy". According to the deadline effect, the closer to the end of the promotion, the stronger consumers' sense of urgency to buy. This "scarcity opportunity" urges consumers to convert potential purchase cognition into an obvious purchase opportunity, which not only ignores the purchase risk, but also emphasizes the acquisition of perceived benefits, resulting in positive perceived value.

Lu and Huang (2014) emphasized that the shorter the promotion duration, the stronger consumers' perception of opportunity cost and the higher their cognitive response to the perceived value of the promotion [49]. Hong (2021) pointed out that when online retailers promote products under the condition of a short time limit promotion and high time pressure, it increases the likelihood that consumers will make a decision to purchase [50]. Accordingly, the following assumptions are proposed:

Hypotheses 9 (H9). *The promotion time limit has a significant positive impact on consumers' perceived value.*

2.2.6. Research Hypothesis of Perceived Trust

Trust is an important variable in the study of consumer behavior. It is generally regarded as a psychological state with positive expectations for the behavior or intention of others [51]. As a prerequisite for online consumers' purchase decision [52], consumer trust is described as a basic element of e-commerce, which can reduce the uncertainty of a purchase and help improve consumers' loyalty and acceptance. Lack of trust will lead to consumer doubt and thereby have a negative impact on their purchase intention [53]. Live commerce is a real-time interactive mode, which contributes to consumers having a sense of subjectivity and intimacy in the interaction. It can be seen that the richer the information content, the more diverse the forms, the higher the timeliness, and the higher the trust of consumers. At the same time, consumers have the pleasure of perceived value based on their trust in this hunger marketing model. Feng and Lu (2020) believe that based on consumers' strong sense of social presence, the webcast environment meets consumers' demand for complete information and promotes consumers' trust in promotion links, which plays an intermediary role in consumers' impulse purchase decisions [54]. Therefore, the following assumptions are put forward:

Hypotheses 10 (H10). *Perceived trust has a significant positive impact on consumers' impulse buying behavior.*

2.2.7. Research Hypothesis of Perceived Value

Perceived value is widely used to predict users' adoption behavior. Product quality, service quality and perceived value have an important impact on customer satisfaction. As a key mechanism to shape these relationships, customer perceived value has become an important consideration in the use and interaction with social media [55]. Zeithaml (1988) first defined customer perception as "the overall evaluation of product effectiveness based on customers' perception of product acceptance and giving" [56]. Bettman (1998) defined customer perceived value as "the value perceived or experienced by customers through the use of a service" [57]. In the time-limited marketing link of the e-commerce platform, perceived value can be regarded as the overall evaluation of product performance by weighing perceived revenue and perceived purchase cost. When consumers feel that the comprehensive evaluation of the economic preference of goods, logistics, after-sales service level and relevant useful information in the broadcast room is higher than their original expectation, it will produce positive perceived value and make them more likely to purchase the item in question. Wang et al. (2021) believe that promotional purchase restrictions, on the one hand, enhance perceived value by highlighting the scarcity of restricted goods, while on the other hand stimulating consumer excitement to satisfy their impulse purchase intention [58]. Accordingly, the following assumptions are proposed:

Hypotheses 11 (H11). *Perceived value has a significant positive impact on consumer impulse buying behavior.*

The above hypotheses, supported by the relevant literature, is explained and incorporated in the research model in Figure 1.

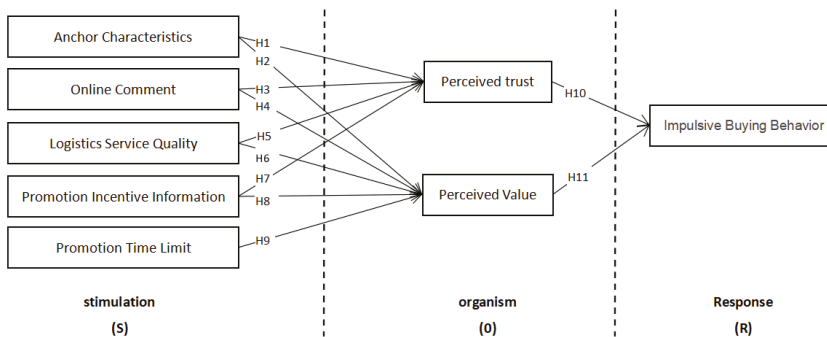


Figure 1. Research model.

3. Questionnaire Design and Data Collection

3.1. Questionnaire Design

In order to verify the assumptions that the researchers have with regard to consumers' online behavior, the questionnaire mainly includes two parts: the first part includes the survey participants' sample demographic characteristics such as gender, age, education, occupation, monthly average income, monthly average online consumption and an empty field where the person can add content, which might include their opinions or suggestions. The second part is the variables and the scale, including "anchor characteristics such as (AC)", "online comment (OC)" and "logistics service quality (LSQ)", "promotion incentive information (PII)", "promotion time limit (PTL)" and "perceived trust (PT)", "perceived value (PV)", "and impulse buying behavior (IBB)". The questionnaire measurement mainly refers to the design of 7-level Likert scale, ranging from (1) completely disagree to (7) completely agree. The detailed description of the questionnaire items is shown in Appendix A.

3.2. Questionnaire Distribution and Data Collection

In order to further ensure the quality of the formal questionnaire samples, the preliminary survey of the questionnaire was carried out. This link will make the questionnaire available in online and offline channels. Online distribution is distributed on major social platforms, while offline distribution is targeted at college students and residents in surrounding communities. In the pre-survey, a total of 80 questionnaires were collected, and five invalid questionnaires were excluded from the survey. The recovery rate of valid questionnaires was 93.8%. Meanwhile, the data passed the skewness coefficient, kurtosis coefficient and reliability test.

The questionnaire was distributed mainly through online channels, primarily to consumers through various online social platforms. Data collection of the questionnaire lasted 75 days from 22 July to 4 October 2021, and a total of 593 users filled in the questionnaire. After screening, 533 valid questionnaires were screened out, with an effective recovery of 89.9%.

3.3. Sample Description

The first part of the questionnaire fully reflects the sample division of 533 valid questionnaires. In terms of gender, males and females accounted for 47.8% and 52.2%. Most of the respondents' ages are between 18–29 (52.9%). 61.2% of interviewees have a Bachelor's degree or junior college degree, and 18.9% of them have a Master's degree or higher, indicating that most of the interviewees have received a good education. By occupation, students were the major participants of this study (35.3%). For further demographic information, see Table 1.

Table 1. Demographic description.

NO.	Characteristics	Category	Frequency	%
1	Gender	Male	225	47.8
		Female	278	52.2
2	Age	Less than 18 Years	10	1.9
		18–29 Years	282	52.9
		30–39 Years	114	21.4
		40–49 Years	48	9.0
		50 + Years	79	14.8
3	Highest Education	Junior high school	15	2.8
		High school/technical secondary school	91	17.1
		Undergraduate	326	61.2
		Postgraduate	101	18.9
4	Occupation	Students	188	35.3
		Civil servant	51	9.6
		Teachers, doctors, banker	56	10.5
		Staff	156	29.3
		Retirees	19	3.6
		Operators	31	5.8
		Others	32	6.0
5	Income	0–1000 Yuan	76	14.3
		1001–3000 Yuan	168	31.5
		3001–5000 Yuan	139	26.1
		5001–7000 Yuan	85	15.9
		7000 + Yuan	65	12.2
6	Online Shopping Consumption	Less than 500 Yuan	284	53.3
		500–1500 Yuan	147	27.6
		1501–3000 Yuan	68	12.8
		3001–5000 Yuan	23	4.3
		5000+ Yuan	11	2.1

4. Results and Discussion

4.1. Reliability Test

A reliability test was used to judge the internal stability of questionnaire data and the reliability of measurement results.

Table 2 shows the mean value, standard deviation, Cronbach's α value and CITC value (the corrected term and the total correlation coefficient) of each item. It can be seen from the calculation results that the mean values of all variables are distributed between 4.33 and 5.12. The standard deviation, Cronbach's α value and CITC value of other variables were consistent with their reference standard values except for the PV1 of variables. These data prove that the questionnaire as a whole has a strong internal consistency. Considering that the value distribution of PV1 items in the perceived value is uneven and the CITC value is lower than the reference value of 0.5, this study deletes the PV1 item to improve the reliability of the data.

4.2. Validity Test

A validity test, as an important means of testing, aims to verify the accuracy of the information reflected in the research content to the required measurement object. This validity test includes convergence validity and discriminant validity.

4.2.1. Convergence Validity

Convergence validity is used to check the consistency within the plane. The factor load of the standardized coefficient reflects the importance of the variable on the common factor, and the factor load of all variables ranges from 0.662 to 0.807, all exceeding the threshold value 0.5. Combined reliability (CR) refers to the reliability of a new variable composed of a combination of several other variables, reflecting whether each measurement item consistently explains the potential variable, and whether the CR value of each variable exceeds the recommended value of 0.7. The AVE value of the mean variance extraction

volume refers to the average variance of the interpretation level of potential variables to observed variables, and the AVE value of each variable that is distributed is between 0.5231 and 0.599, all of which are more than 0.5. It can be judged that the convergence validity of the sample data meets the standard.

Table 2. Reliability Checks.

Latent Variables	Number of Items	Measuring Item	Mean	Standard Deviation	CITC	Cronbach's α after Deleting the Item	Cronbach's α
Anchor Characteristics (AC)	5	AC1	4.48	1.552	0.696	0.847	0.873
		AC2	4.47	1.532	0.700	0.846	
		AC3	4.34	1.471	0.713	0.843	
		AC4	4.76	1.487	0.709	0.844	
		AC5	4.72	1.529	0.680	0.851	
Online Comment (OC)	5	OC1	4.81	1.482	0.597	0.823	0.842
		OC2	4.87	1.470	0.711	0.792	
		OC3	4.62	1.575	0.601	0.823	
		OC4	4.63	1.513	0.673	0.813	
		OC5	5.04	1.387	0.697	0.798	
Logistics Service Quality (LSQ)	5	LSQ1	4.85	1.482	0.665	0.868	0.881
		LSQ2	4.90	1.519	0.737	0.851	
		LSQ3	4.86	1.445	0.727	0.853	
		LSQ4	4.90	1.455	0.725	0.854	
		LSQ5	5.05	1.432	0.727	0.854	
Promotional Incentive Information (PII)	5	PII1	4.33	1.579	0.631	0.850	0.865
		PII2	4.55	1.574	0.695	0.834	
		PII3	4.56	1.521	0.679	0.838	
		PII4	4.60	1.539	0.698	0.833	
		PII5	4.66	1.493	0.727	0.826	
Promotional Time Limit (PTL)	4	PTL1	4.70	1.387	0.631	0.770	0.815
		PTL2	4.64	1.571	0.623	0.773	
		PTL3	4.58	1.482	0.648	0.760	
		PTL4	4.64	1.540	0.637	0.765	
Perceived Trust (PT)	4	PT1	4.56	1.383	0.683	0.824	0.856
		PT2	4.54	1.374	0.722	0.807	
		PT3	4.71	1.377	0.677	0.826	
		PT4	4.69	1.342	0.714	0.811	
Perceived Value (PV)	4	PV1	4.80	2.192	0.403	0.827	0.742
		PV2	4.93	1.331	0.684	0.619	
		PV3	5.12	1.333	0.588	0.666	
		PV4	4.89	1.387	0.619	0.646	
Impulse Buying Behavior (IBB)	5	IBB1	4.70	1.608	0.711	0.879	0.895
		IBB2	4.98	1.534	0.752	0.869	
		IBB3	4.83	1.562	0.765	0.866	
		IBB4	4.95	1.525	0.771	0.865	
		IBB5	4.97	1.482	0.709	0.879	

4.2.2. Discriminative Validity

Discriminant validity is used to test the degree of difference between a given facet and other facets, and the observed facets can be distinguished from each other. As shown in Table 3, the AVE arithmetic square root values of the diagonal lines are much higher than the values of the relevant factors in the same column, indicating that each potential variable can be distinguished from each of the others by high discriminant validity.

Table 3. Discriminant validity.

	AVE	PTL	PII	LSQ	OC	AC	PT	PV	IBB
PTL	0.525	0.725							
PII	0.523	0	0.723						
LSQ	0.599	0	0	0.774					
OC	0.523	0	0	0	0.723				
AC	0.578	0	0	0	0	0.761			
PT	0.540	0	0.231	0.281	0.059	0.506	0.735		
PV	0.542	0.098	0.480	0.274	0.173	0.095	0.246	0.736	
IBB	0.592	0.039	0.265	0.196	0.088	0.192	0.404	0.48	0.769

4.3. Modification of Structural Equation Model

The structural equation model (SEM) is based on the covariance matrix and is designed to analyze the relationship between variables. The sample covariance matrix is equivalent to the model covariance matrix and determines whether the sample data and the hypothesis path analysis model match. In order to increase the comparability between variables, the model was modified in this study. It can be seen from the results that the standardized factor load of potential variables of each measurement model is distributed between 0.664 and 0.833, which is higher than the standard value of 0.6, and the SMC (square multiple correlation) value is distributed between 0.441 and 0.685, higher than the standard value of 0.36. According to the revision suggestions in the analysis report, it can be seen that the PT3 measurement has a great correlation with PT1, PT2 and PT4, which should be removed according to the revision suggestions. The modified normalized path diagram and the fitting index of the structural equation model are shown in Figure 2 and Table 4.

Table 4. Structural equation model fit index.

Fitness Index	Standard Values	Actual Value	Results
Chi-square value(X ²)	-	1610.673	Supported
Degrees of freedom (DF)	-	594	Supported
Significance level(P)	< 0.05	0.000	Supported
X ² /DF	< 3	2.934	Supported
Fitness index (GFI)	>0.9	0.832	Acceptable
Root mean square of approximate error (RMSEA)	< 0.08	0.060	Supported
Comparative fitness index (CFI)	>0.9	0.891	Acceptable
Standard fit index (NFI)	>0.9	0.844	Acceptable
Increasing adaptation index (IFI)	>0.9	0.891	Acceptable
Simplified benchmark adaptation indicators (PNFI)	>0.5	0.779	Supported
Reduced fit index (PGFI)	>0.5	0.725	Supported
Noncanonical fit index (TLI)	>0.9	0.882	Acceptable
Adjusted fit index (AGFI)	>0.8	0.808	Supported
HORLTER	>200	200	Supported

The nonstandardized path coefficient is used to verify the existence of the influence relationship between variables, and the standardized path coefficient is used to judge the strength of the influence relationship between variables. According to the path coefficient data displayed by AMOS. using the maximum likelihood estimation method, the standardized and non-standardized path coefficients are plotted into tabulated statistics, and the results are shown in Table 5.

Table 5. Path coefficient test results.

Hypothesis	Content	Normalized Path Coefficient (Std.)	Nonstandardized Path Coefficient (UStd.)	Standard Error (S.E.)	Critical Ratio (C.R.)	p	Results
H1	PT < -AC	0.497	0.429	0.050	8.632	***	Supported
H2	PV < -AC	0.092	0.076	0.044	1.740	0.082	Not Supported
H3	PT < -OC	0.036	0.037	0.058	0.636	0.525	Not Supported
H4	PV < -OC	0.173	0.169	0.058	2.923	***	Supported
H5	PT < -LSQ	0.229	0.284	0.051	5.530	***	Supported
H6	PV < -LSQ	0.275	0.249	0.050	4.942	***	Supported
H7	PT < -PII	0.224	0.208	0.052	3.977	***	Supported
H8	PV < -PII	0.480	0.426	0.057	7.469	***	Supported
H9	PV < -PTL	0.097	0.094	0.051	1.831	0.067	Not Supported
H10	IBB < -PT	0.301	0.332	0.058	5.721	***	Supported
H11	IBB < -PV	0.412	0.477	0.063	7.629	***	Supported

Note: *** $p < 0.001$; $p > 0.05$ (not significant).

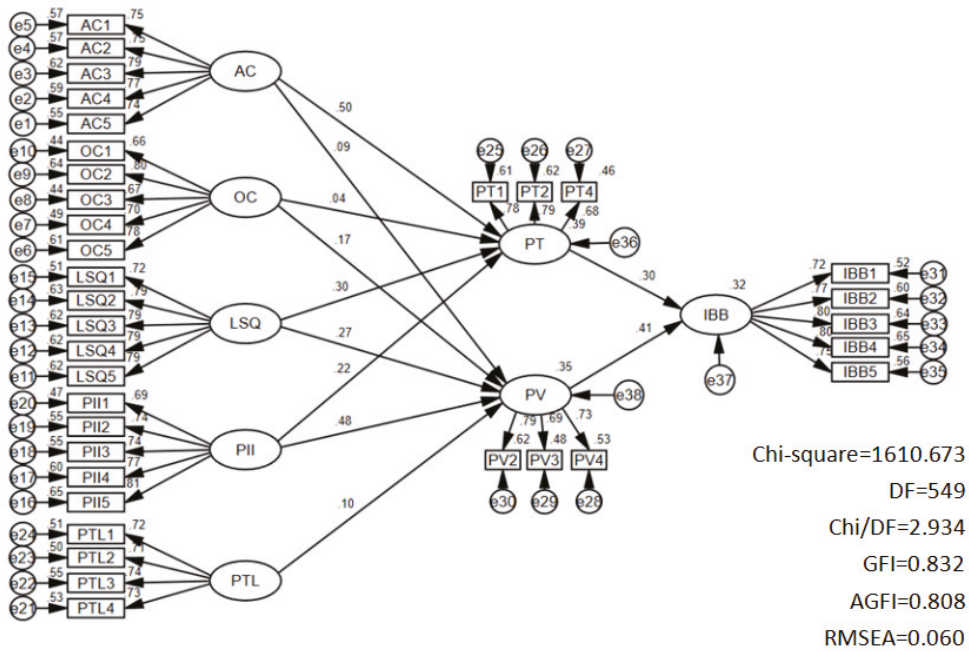


Figure 2. Normalized path coefficient diagram.

5. Conclusions and Empirical Analysis

According to the path coefficient test results of the research hypothesis model in Table 5, the test results and empirical analysis of this study can be interpreted as follows:

1. The influencer characteristics have a significant positive impact on consumers’ perceived trust ($\gamma = 0.497, p < 0.001$). Therefore, H1 was supported. This also confirms that in the hunger marketing mode, influencers provide comprehensive and professional explanations of product information and activity information with their rich professional knowledge and sales experience to bring consumers a sense of intimacy. They have established a bond of trust between consumers on platforms, products and services [59].
2. The effect of influencer characteristics on consumers’ perceived value fails to reach a significant level ($\gamma = 0.092, p = 0.082$). Thus, H2 was untenable. This may be because before the influencers explain the preferential content, the product links on the platform have more or less introduced the product information and created preferential intensity or created initial impressions [60], which makes the influencers have certain psychological expectations of consumers in the process of explaining. Therefore, the influencer factor is not obvious in consumers’ determination of perceived value.
3. Online reviews have no significant effect on consumers’ perceived trust ($\gamma = 0.036, p = 0.525$). H3 was not assumed. There are two reasons for this: on the one hand, there are a large number of participants in the broadcast room and the scrolling speed of online comments is fast, making it difficult for consumers to capture useful information. On the other hand, due to the difficulty of supervision, chaos emerges in endless streams, and there are more malicious bad comments from competitive businesses in the comments, resulting in a mix of bad information. It is difficult for consumers to distinguish the quality with regard to real-time reviews, resulting in reduced trust in real-time review valence.

4. Online comments have a significant positive effect on consumers' perceived value ($\gamma = 0.173, p < 0.001$). Therefore, H1 was supported. Consumers are immersed in a strong sense of social presence by participating in real-time online reviews. Personal reviews also have a strong impact on consumers' perceived value and purchasing decisions. This effect is particularly pronounced when individual reviews help consumers resolve product uncertainties or contrast with aggregated information that is readily available on product pages [61].
5. Logistics service quality has a significant positive impact on consumers' perceived trust ($\gamma = 0.229, p < 0.001$) and perceived value ($\gamma = 0.275, p < 0.001$). H5 and H6 were supported. Faced with consumer demands for various logistics services, e-commerce enterprises can not only guarantee basic logistics services, but also launch other differentiated value-added services. This not only improves consumers' credit evaluation of online shopping, but also helps to reduce consumers' perceived risk and guarantee the promise of after-sales support [35].
6. Promotional incentive information has a significant positive impact on consumers' perceived trust ($\gamma = 0.224, p < 0.001$) and perceived value ($\gamma = 0.480, p < 0.001$). H7 and H8 were supported. Most of today's consumers are price-sensitive with utilitarian value appeals. Online promotions are favored by hedonistic consumers [62]. The promotion and incentive information of e-commerce can be fully interpreted in the warm-up process and marketing process, and a proper promotion strategy will win the trust of consumers. The activity intensity of goods makes consumers perceive the lure of promotional benefits, which not only deepens their sense of identity to the enterprise, but also effectively improves consumers' perceived value and increases the likelihood that they will make impulse purchase decisions.
7. The promotional time limit has no significant positive effect on consumers' perceived value ($\gamma = 0.097, p = 0.067$). H9 was not accepted. In the broadcast room, the hunger marketing strategy will have a time limit on preferential products and create opportunities for scarcity in order to incite consumers to purchase in large quantities. However, it is generally seen that the frequency of live commerce and the number of product events by merchants have increased significantly compared with the past, which has increased the opportunities for consumers to snap up quantity restricted products, and the promotional time limit is not the only opportunity for them to purchase these particular items, leading consumers to postpone purchases indefinitely. In addition, the fact that consumers are busy will weaken their tendency to wait for time-limited discount purchases [63], and the perceived value level of the hunger marketing model will weaken.
8. Consumers' perceived trust ($\gamma = 0.301, p < 0.001$) and perceived value ($\gamma = 0.412, p < 0.001$) both have a significant positive impact on impulse buying behavior. H10 and H11 were supported. Whether because the live commerce scene simulates the offline stores, or whether merchants and influencers comprehensive introduction of product and activity rule information [64] enhance trust, or whether it is because of the influence of other factors, it will have a certain impact on consumers' trust. It is because of consumers' trust in this kind of hungry marketing mode that consumers' complete demand for online shopping is met. At the same time, the rapid development of the e-commerce network shortens the space and time distance between products and consumers, and endows them with higher value. Compared the amount of time, energy and money, when consumers get caught up in the overall feelings referred to in the hunger marketing model, and particularly feel the urge to make a purchase because of time restrictions under the constraints of the perception of an opportunity cost, this generate a positive perception of an item's value, and the feasibility of the impulse buying behavior will be stronger.

6. Research Suggestions and Limitations

6.1. Research Suggestions

From all the collected questionnaire information and the analysis of the research results, we can find that the consumer acceptance of the hunger marketing in live commerce is relatively high. However, some problems existing in some links in the purchase process will also affect consumers' continuous repurchase. In order to help the sustainable development of live commerce, we put forward the following suggestions for the shortcomings of the hunger marketing mode adopted by live commerce.

6.1.1. Anchor

The behavior of e-commerce anchors most directly affects consumers' awareness of product information and activity content. In recent years, e-commerce anchor has become a popular career which has a low threshold but high income, resulting in the uneven quality of live commerce anchors. Therefore, e-commerce platforms should hire anchors with a certain level of popularity, professional knowledge, and a good image and temperament. Meanwhile, in order to improve customer satisfaction, anchors should not only introduce product information and in detail on the live broadcast, but also possess other qualities that enable them to reply to customer questions accurately and in a timely manner, with emphasis on their positive interaction with consumers. If necessary, the mode of "professional anchor + popular flow" can be adopted to ensure the popularity of live commerce.

6.1.2. Online Comments

Online real-time comments are an important factor for consumers to integrate into the hunger marketing model. E-commerce merchants should attach importance to the interactions in the comment sections and actively respond to the questions found there. In order to attract more consumers to participate in live broadcasts, e-retailers can use the review section as a platform to enrich the form of activities add interactive links, so as to increase the purchase rate. In addition, businesses should also be vigilant and strengthen measures to reduce the occurrence of malicious fake reviews.

6.1.3. After-Sales Service

After-sales service quality has a significant impact on the performance of online retailers [65]. Ensuring after-sale service is a necessary measure to eliminate consumers' misgivings. Therefore, merchants should make wise measures, such as improving after-sales quality assurance security, adding seven-day return service without conditions attached, and adding complimentary freight insurance in order to enhance consumer confidence that they are having a worry-free purchase experience.

6.1.4. Promotional Incentive Information

The lower price and relevant preferential activities are often the things that consumers notice the most. However, due to the improper publicity of the enterprise in the early stage, many potential consumers do not receive the activity information, which in the loss of customers for the business. Therefore, businesses should promote through multiple channels that are widely spread through various ways to let consumers know the facts, improve the weight of livestreaming numbers, and create promotional policies. At the same time, high-quality live commerce incentives can help improve consumers' experience and increase their desire to buy. In the selection of products, businesses should be more strictly with the supply to ensure that product quality remains as the core priority. At the same time, they should ensure that the preferential policies are understandable and true, and make the price comparisons between live commerce platforms transparent. In the process of live commerce, they should try to increase the distribution of discounts and coupons for goods, and adjust the frequency of time-limited promotions according to the attributes of the goods [66]. When necessary, businesses can meet consumers' demand for "price

protection”, establish a good brand image, improve pre-sale standards, improve after-sales mechanisms, and protect the interests of the platform, of the sellers, and of the consumer.

6.1.5. Promotion Time Limit

The setting of time limits for promotions is the most controversial aspect of e-commerce platforms. The length of promotion time will directly affect consumers’ buying mentality. Setting time limits is the hard part of buying campaigns. If it lasts too long, consumers will think that waiting is a waste of their time. Too short a buying time will give people a sense of urgency. In addition, we found that the frequency settings of live commerce events also need to be optimized. The excessive frequency of live commerce of restricted goods will reduce consumers’ perceived value of the item in question. However, if the frequency is low, consumers will be irritated because they cannot purchase the goods in question. Accordingly, the improvement of the promotional time limit can be carried out in the following manner. First, merchants should set the expected sales volume according to the expected response. Second, a fixed start time should be set, and a timely notice of the time of buying should be given to the consumer in order to avoid the loss of customers. Third, a promotional buying time should be set so that consumers can receive information and consider the potential purchase rationally on the basis of the same acquisition process of perceived pleasure.

6.1.6. Promotional Program Setting

In order to enhance their popularity and gain more exposure, businesses will ask consumers to complete some tasks during the live commerce event in order to qualify to purchase of the item being advertised. Too many routines and tedious steps in this process will reduce consumers’ purchasing motivation. It is suggested that direct broadcast promotion procedures be simplified. Businesses should establish the connection between consumers and brands by designing reasonable promotional programs to ensure the consumers’ purchasing enthusiasm [67], so as to increase the likelihood that the customer will return to make future purchases, while at the same time addressing the concerns of consumer groups.

6.2. Research Limitations

Despite our new findings and recommendations for the sustainability of live commerce, this article has some limitations. We used online questionnaires, and the arbitrary attitudes of some respondents may have a certain influence on the research results. In the future, we might consider adding offline filling channels in order to help researchers understand consumers’ intuitive feelings about e-commerce live broadcasts in person and thereby draw more comprehensive research conclusions. In addition, there may be limitations in the selection of external stimulus influencing factors. In the future, we will try to consider more factors.

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Appendix A

Table A1. Questionnaire item.

Latent Variables	Serial Number	Measuring Item
Anchor Characteristics (AC) [68,69]	AC1	When watching the live commerce, I think the anchors will respond to my questions in a timely manner.
	AC2	The communication and interaction of the anchors made me feel that the live commerce marketing activity was very valuable.
	AC3	I think the product information recommended by anchors for me is authentic and credible.
	AC4	Through the direct experience of the anchor to the product, I deepened my understanding of the product.
	AC5	I think anchors are familiar with the product and have professional knowledge, so they can explain clear and accurate activity information.
Online Comments (OC) [70–72]	OC1	I take the initiative to read the feedback of the online comments in the studio.
	OC2	I choose to buy items with a high number of real-time reviews.
	OC3	I tend to be drawn to extreme (positive or negative) real-time comments.
	OC4	I can share my shopping tips with other customers through real-time online reviews.
	OC5	The content of real-time product reviews has an impact on my purchase decision.
Logistics Service Quality (LSQ) [73]	LSQ1	The timely and accurate processing of orders on e-commerce platforms encourages me to snap up goods.
	LSQ2	Merchants offer value-added services such as “seven-day no-excuses returns” and “instant refunds” to encourage me to snap up goods.
	LSQ3	If the logistics company cooperating with the merchant can promise to deliver the goods on the scheduled time, I will consider snapping up the goods.
	LSQ4	When the distribution range of logistics outlets meets my needs, I will consider buying goods.
	LSQ5	When the e-commerce platform can timely deal with my return or replacement requirements, I will consider buying goods.
Promotional; Incentive Information (PII) [48,74]	PII1	I will always pay attention to the promotional prices and coupon information released in the live commerce.
	PII2	When buying goods, I like to buy promotional goods in the broadcast room.
	PII3	Livestreaming promotions allow me to get a more reasonable consumer price.
	PII4	The price discount in the broadcast room makes me feel very generous.
	PII5	The buying in the studio makes me feel more affordable.
Promotion Time Limit (PTL) [75]	PTL1	I feel that the sale time of the broadcast room is usually relatively short.
	PTL2	I feel like I have less time to decide if I want to buy something that’s on sale live.
	PTL3	I feel like I’m snapping up sales right before the deadline.
	PTL4	The closer I get to the end of a limited-time sale, the time pressure pushes me to buy as quickly as possible.
Perceived Trust (PT) [76,77]	PT1	I think e-commerce live commerce platforms are trustworthy.
	PT2	I think the promises made by e-commerce platforms are reliable.
	PT3	If there is a problem with the product, I believe the merchant will try his best to provide me with a solution.
	PT4	I think e-commerce platforms can provide enough commodity information and quality services.
Perceived Value (PV) [78]	PV1	I think the products recommended in the e-commerce live commerce just meet my needs.
	PV2	The sales promotion makes me feel economical.
	PV3	When I participate in a sale, I feel good about getting a good deal.
	PV4	I feel it’s very cost-effective to snap up sales.
Impulse Buying Behavior (IBB) [79]	IBB1	When I watch the livestream of e-commerce, I often buy something that I didn’t intend to buy.
	IBB2	When I watch the live commerce, I often find some goods I want to buy that are not in my plan.
	IBB3	In the flash sale, I will have a strong desire to buy goods.
	IBB4	I have a sudden urge to buy something during a flash sale.
	IBB5	After reading the preferential content of the product, I have a great possibility to buy.

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Article

Challenges and Perspectives in Innovative Projects Focused on Sustainable Industry 4.0—A Case Study on Polish Project Teams

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Abstract: Contemporary project teams are increasingly used to solve problems that are at the crossroads of many disciplines and areas dedicated to Industry 4.0, which is a watershed in the implementation of Sustainable Development Goals (SDGs). Industry 4.0 can serve as a platform for the alignment of SDGs with the ongoing digital transformation. This involves specific challenges for teams, but also allows perspectives that may create innovative and high-quality results. In order to meet these challenges while taking advantage of the opportunities offered by interdisciplinary cooperation, project teams, including the team leader, should have specific competencies. With this in mind, the aim of this article is to identify the challenges and perspectives related to working in interdisciplinary Sustainable Industry 4.0 project teams and to define the competencies necessary to act as a member and leader of these teams. Implementation of this aim will be possible by answering two research questions: (1) What requirements and opportunities are involved with interdisciplinary work amongst members of Sustainable Industry 4.0 project teams; and (2) What are the competencies necessary of members and leaders of such teams to meet these requirements and take advantage of the opportunities for such cooperation? An exploratory case study was conducted among members of interdisciplinary project teams at one of the leading technical universities in Poland. Qualitative data were obtained from many sources: interviews, internal documentation of analyzed projects and managerial notes. The obtained results allow us to state that the most important challenges and perspectives related to the work of interdisciplinary Sustainable Industry 4.0 teams include coordination of individual parts of the project, integrative leadership, establishing a common language, broad views on the issues raised and building a team consisting of specialists with the required competencies. The competencies of the project team that are important for working in the analyzed environment include strategic perspective, communication skills and persuasion, while for leaders, competencies must include the ability to coordinate work, resource management, empowering and motivation.

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Keywords: Sustainable Industry 4.0; innovative projects; interdisciplinarity; project team competencies; leadership

1. Introduction

Over the past centuries, as a result of industrial revolutions, society has experienced significant changes and technological progress [1]. Industry 1.0 was characterized by introducing machines to industrial processes [2]. Industry 2.0 was related to the concept of multi-scale production, reduction of costs and lead time, and the introduction of technical and organizational innovations [3]. The next age, Industry 3.0, was associated with the development of technological information systems [4]. Currently, the fourth stage of industrialization (Industry 4.0) affects the creation of industrial value in the most-developed countries. Industry 4.0 is treated as the beginning of a new era in which industry is becoming more and more “intelligent” thanks to the use of Internet of Things technology, predictive analysis and intensive data exchange [5,6]. Industry 4.0, as many researchers (e.g., ref. [7]) emphasize, also changes the way of performing and controlling tasks related to project

management as projects become more complex, innovative, and implemented at the crossroads of many areas of the economy. Industry 4.0 is also a sociotechnical concept that can support the entire society and industry in achieving sustainable development [8–11]; hence, this stage of the revolution can be called Sustainable Industry 4.0. Considering the above, it becomes necessary to more deeply understand the challenges and perspectives that project team management brings with it in an environment that is strongly connected to Sustainable Industry 4.0 and to undertake an analysis of the required competencies of members and leaders of such project teams.

Sustainable Industry 4.0 is the new path of organization and control for systems with full added value, and its overriding goal is to satisfy the individual needs of customers with the costs of mass production. On this account, work in an economy based on Sustainable Industry 4.0 means behaviors and skills [12] required from employees, including project team members, must enable them to meet the challenges of Sustainable Industry 4.0. The need for a new approach to human resources management in the era of Industry 4.0 is emphasized by many researchers (e.g., ref. [13]), who point out that Sustainable Industry 4.0 may create a need for a management paradigm shift. Nevertheless, as researchers (e.g., ref. [14,15]) emphasize, analyses in the context of Sustainable Industry 4.0 mostly refer to the new technologies driving this revolution, and the literature on the human factor in the area of Industry 4.0 is still narrow and rare, which necessitates more research in this area.

Sustainable Industry 4.0 is an excellent opportunity to take a real step towards better performance and strategic value creation by organizations [16]. For this reason, more and more references related to Sustainable Industry 4.0 can be found in various citation databases today [17]. These considerations focus on the concept of Sustainable Industry 4.0 in the context of project management. Ref. [18] points out, the role of project management is crucial for the success of Sustainable Industry 4.0 and vice versa. Therefore, many researchers emphasize the need for further work in this area to provide a more in-depth analysis of the use of project management during the 4th Industrial Revolution. Ref. [19], on the basis of their analysis of the main research areas in project management and activities covered by the 4th Industrial Revolution, identified human resource management as one of the common themes for future analysis in this area. The relevance of this topic from the point of view of the discussed issues is also indicated by other researchers. For example, ref. [20,21] emphasize that Sustainable Industry 4.0 influences project management and makes it necessary to change the way projects are implemented and the interaction between team members. It also forces project teams to develop new competencies necessary for activities within the 4th Industrial Revolution. Similarly, ref. [22] points out that project managers and teams will require higher soft and hard skills than needed in the past, and more autonomy in handling Sustainable Industry 4.0 projects. Ref. [23] adds that Sustainable Industry 4.0 challenges the project managers in different ways.

Moreover, it should be noted that 4.0 projects are characterized by higher complexity and uncertainty, which requires a flexible approach to solved problems and interdisciplinary work. Ref. [7] draws attention to that, also pointing out that the two main theoretical attributes of project management—uncertainty and complexity—also play a significant role in Sustainable Industry 4.0 projects because they shape and define the necessary features to support the workload and are associated with increasing project complexity. Therefore, as [24] indicates, project teams in Sustainable Industry 4.0 must be self-organizing, interdisciplinary, real-time and autonomously optimized. This is also emphasized by the authors of [25], who state that project management in Sustainable Industry 4.0 is characterized by digitization, virtualization, transnationality, professionalization, the transition from Waterfall to Agile, focus on the project–organization relationship and organization maturity in project management. The complex problems that characterize Sustainable Industry 4.0 projects, as many authors emphasize (e.g., ref. [24]) and is also emphasized above, require interdisciplinary cooperation. However, based on analysis of the literature, it can be concluded that analyses related to interdisciplinary cooperation of teams operating in the 4.0 environment are rare.

The motivation for this article was to identify ways in which the changes accompanying the 4th Industrial Revolution affect the new requirements for workers from many industries and sectors, and the aim of this article is to develop a theoretical and empirical understanding of how the changes caused by the 4th Industrial Revolution affect the competencies of project teams. Although research and practice show that in order to achieve the sustainable implementation of technologies supporting Sustainable Industry 4.0, a new approach to human resource management will be necessary, including, in particular, the acquisition and improvement of appropriate competencies by employees, including members of project teams. However, streams of literature connecting management projects and human resource management have not been largely integrated into Sustainable Industry 4.0 literature. The absence should be seen as a problem, because research of various disciplines suggests (e.g., ref. [2]), that, in the face of future trends of the 4th Industrial Revolution, it is necessary to develop a new management paradigm, which will be largely based on the interdisciplinary cooperation of competent teams, and their lack is seen as the main threat to economic growth and should be a top priority in the agendas of enterprises and policy makers. Further, management literature indicates that the development of employee competencies is necessary in rapidly changing industries and sectors, as is the case in industries and sectors of Sustainable Industry 4.0, so that companies can adapt to changing conditions [26]. Taking into account the above, a case study of project team members at one of the leading technical universities in Poland between February 2019 and September 2020 was conducted in this article. The obtained results fill the research gap concerning the requirements of Sustainable Industry 4.0 for members of project teams, and are some of the first to indicate the necessary competencies in this area. What is more, the inclusion of interdisciplinary project teams in the analysis of the interdisciplinary context makes these considerations original, as they are overlooked or considered in a very narrow scope and can provide a basis for shaping and improving the selection process of interdisciplinary teams in the area of Sustainable Industry 4.0.

2. Literature Review

2.1. Sustainable Industry 4.0

Industry 4.0 is treated as the 4th Industrial Revolution [27]. It includes a number of new technologies influencing new digital value chain creation as well as the digitization and automation of the production environment. The 4th Industrial Revolution is based on development of intelligent systems that enable system monitoring and decision making in real time [28]. A new paradigm appears here, focused on modern enterprise management based on new technologies enabling integrated optimization of processes [7]. This paradigm results from the combination of production systems, which on the one hand are vertically connected to the company's business processes, and, on the other hand, horizontally connected to other points in the value chain in order to increase efficiency and response time to each request, with the customer being the main target [29–31]. It can therefore be concluded that the transition to Sustainable Industry 4.0 and the development of cyber-physical systems introduces technical, organizational and human changes in various organizational layers of enterprises [32,33].

Although the 3rd Industrial Revolution was marked by simple digitization, the 4th Industrial Revolution has an inexorable shift in this simple digitization, where the rush of innovation comes from many combinations of technology in new forms. The 4th Industrial Revolution can be distinguished from others for three reasons: (1) Speed—the interconnectivity of the world increases at an exponential rate, and the emergence of new technologies generates further innovation. (2) Breadth and Depth—taking the 3rd Industrial Revolution as a reference, the 4th Industrial Revolution integrates and expands various technologies. (3) Systemic Impact—entire systems are transformed within countries, companies, value creation networks or in society in general [24]. Therefore, despite the many advantages of Sustainable Industry 4.0, this new era of industry is also associated with a number of challenges for many organizations. Examples of such challenges are technology integration,

data security, organizational transformation [34], acquisition and implementation of appropriate information technologies, distribution of decisions, encouragement to experiment with new ideas in the workplace [35] and greater complexity of projects [36]. Consequently, these challenges are reflected in new requirements for employees, changing professional profiles of employees and employment structures. The change of professional profiles especially is characterized by a change in the required competencies of employees. Examples of such desirable competencies include abstract and analytical skills, openness to changes and knowledge in the field of data processing [37]). Much emphasis is also placed on active individual development.

In their research, ref. [38] divided professional profiles into two groups: 4.0 and non-4.0 profiles, and then assessed the differences between the skills of these profiles, dividing the skills into three groups: everyday execution, operational abilities and functional abilities. The operational skills consisted of hard and transversal skills. The everyday skills cluster included eight abilities (e.g., business acumen, project management, change management and problem solving). All of them were of a cross-sectional character, and many of them also had a methodological character (e.g., project management and change management). On the other hand, the functional cluster included 28 skills, both hard and cross-sectional. The results of these studies show that the average level of vertical skills, such as operational and functional, turn out to be the same for both 4.0 and non-4.0 profiles. Transversal skills, in turn, prove to be much more appropriate for 4.0 profiles. This indicates that there is an important soft component to manage and face the introduction of new technologies [39]. The importance of soft skills in the digital age is also emphasized in many other studies, e.g., ref. [40–42], where they are indicated as resistant to change and a vital new component of the workforce of the future, not just the key to differentiate people from machines.

Ref. [43] pointed out that the main skills that can best influence the context of Sustainable Industry 4.0 are based on three skill groups: cognitive skills, interpersonal skills and strategic skills. In the interpersonal leadership group, the most outstanding competencies are negotiation, persuasion and social perception. In the case of the strategic leadership group, the most significant competencies are vision, identification of key requirements and system and solution assessment. For the cognitive group, the important competencies are communicative skills, active listening, learning and critical thinking. Ref. [44], in turn, identified two sets of leadership skills necessary in Sustainable Industry 4.0: one related to human relationships and the other related to knowledge about the use of technology. The main leadership skills were listening, teamwork, stakeholder relations, team member relations, use of digital tools and ability to deal with change.

Moreover, ref. [38] proved that significantly important competencies for 4.0 professions are abilities such as business acumen, project management and change management, in which the difference between 4.0 and non-4.0 profiles is substantial, and which play a key role in the context of renewal.

2.2. Project Management in Sustainable Industry 4.0

In Sustainable Industry 4.0, a faster and more dynamic flow of information is expected. Working groups will cover very different areas of knowledge and will be varied. There will be development and use of more predictive and faster management tools. The use of Big Data tools will enable rapid flow of huge amounts of information with a wide spectrum. Robotization of the industry will increase its efficiency, but under certain circumstances it can also remove the human factor [45]. All these factors will cause significant changes in the form of management, and thus also in project management [7].

The contribution of the human factor in project activities related to Industry 3.0 is visible and observed in all processes that make up project management. The tasks carried out within the project are defined here, timed and used as a project management and control instrument covering all activities ranging from initiation to completion of the project. Initiating, planning, implementing, monitoring and controlling the project, as well as the

processes related to closing the project, are subprocesses of the classic approach to project management [45] and are implemented in Industry 3.0 projects. In contrast, Sustainable Industry 4.0 projects are individual-customer driven. For this reason, order management applies to all areas, such as research and development, production, commissioning, delivery and recycling of manufactured products. It is also particularly noticeable in the production sector, which today is pioneering Sustainable Industry 4.0, and in which the human factor is gradually replaced by machines, and the subprocesses of applying, monitoring and controlling are fully automated. In this case, initiation and planning processes take on more importance than in the classic approach to project management, and identification of the human factor involved in project initiation and planning requires restructuring to include its functions during the implementation, monitoring and control of the project [25]. This is also emphasized by [46], who indicate that, unlike “classic” projects, sustainable Industry 4.0 projects are characterized by an unclear purpose and/or unclear solution, therefore an important aspect here is the phase of gathering and identifying information that is missing in the implementation of “classic” projects.

In addition, in the era of Sustainable Industry 4.0, new opportunities are the digitization of production using base, cyber–physical production systems. This is why resources, such as all employees, products, resources and systems, must additionally be integrated as intelligent, self-organizing, interdisciplinary, real-time and autonomously optimized. This is also pointed out by [46], who emphasize that 4.0 projects are increasingly becoming interdisciplinary projects that combine various project grounds that can no longer be clearly separated from each other. Moreover, as the authors point out, management of 4.0 projects encounters barriers related to such issues as: insufficient change management, corporate culture inhibiting innovation, insufficient support and quality of decision making by managers, or the lack or inadequately planned project characteristics.

Project management in Sustainable Industry 4.0, through manifestation of its characteristic elements, will have a significant impact on the planning and implementation of projects in various areas of activity. For example, the new function of project management in Sustainable Industry 4.0 projects will be as follows: In the area of time management—real-time monitoring of project execution and eliminating gaps in progress reports; In the area of team management—generalize the use of virtual teams and collective intelligence; In the area of communication management—accelerate communication processes within projects, remove physical communication support and increase connectivity [7]. These changes can also be emphasized in the soft and hard skills of project managers and their team members. In Sustainable Industry 4.0, the soft skills of project managers will undergo a significant transformation mainly related to new ways of interacting with project stakeholders. There will be important soft skills such as [22]: communication skills, power, team management, management of unforeseen events and negotiating skills. Therefore, the project manager should build their authority on the basis of 360-degree knowledge of the project and the related field. In order for the team to operate effectively, communication should be carried out in a transparent and responsible manner.

2.3. Interdisciplinary Project Teams

Working in interdisciplinary project teams is becoming increasingly popular [47–50] due to their increasing use in the development of the new processes and products [51] required by Sustainable Industry 4.0. This also affects the composition of project teams, as team members should be highly qualified and have diverse competencies. Therefore, a very important issue, already at the stage of defining the resources necessary for project implementation, is the proper selection of employees for the project team [52].

The work of project teams in an environment such as Sustainable Industry 4.0—which, therefore, is subject to constant innovation—requires team members not only to develop technical knowledge and hard skills, but also necessitates changes in behavior and development of soft skills, among which interdisciplinarity is emphasized [53]. Ref. [54], analyzing the new skills of teams necessary for Sustainable Industry 4.0, indicates that the most

frequently mentioned skills include interdisciplinary thinking, problem solving, flexibility and creativity, and adds that the need for interdisciplinary thinking is a consequence of the high complexity of knowledge (tacit and explicit) in companies. In this context, ref. [55] also emphasizes education of team members must be adapted to new teaching and learning models that focus on developing interdisciplinary competencies and increasing employees' ability to solve problems and face the challenges resulting from the 4th Industrial Revolution. This is also emphasized by [56], pointing out that it is important for organizations to remodel the learning process and develop interdisciplinary competencies that will increase the capacity of team members in problem solving, creativity, and innovation.

Moreover, in the case of 4.0 projects that are realized in a dynamic environment that is constantly changing and for which the goals cannot be clearly defined at the beginning, agile approaches to project management become important [57]. Agile project management is characterized by an iterative and adaptive approach, consisting of short, customer-oriented feedback loops, formal and informal communication, and enabling self-organization in interdisciplinary teams [58]. In addition, the agile approach allows project teams to respond to emerging needs in a timely manner [59–61], which is extremely important in the context of the 4th Industrial Revolution, which is aimed at meeting rapidly changing preferences, customers and available technologies.

The interdisciplinary teams behind [62] are those in which the team uses the information, data, techniques, tools, perspectives, concepts and/or theories available within different disciplines or groups of expertise to solve an issue that goes beyond the scope of one discipline or area of research. Of course, the project team itself has, by definition, distributed roles and expertise [63], but in the case of interdisciplinary project teams, we deal with a different type of skills and highly specialized knowledge from several disciplines, professions, organizations or nations. Moreover, it should be noted that degrees of distributed knowledge and expertise likely vary according to project team type; therefore, when considering an interdisciplinary project team, we are dealing with integrated project teams that have multiple varied goals that must be clarified across their heterogeneous membership and multiple work cycles. Furthermore, such a team must integrate extremely large amounts of information, as processes and routines must be adapted or created for managing and executing projects [63].

The main challenge in interdisciplinary team cooperation is overcoming the disciplinary gap, but often, also, the form of cooperation itself. Interdisciplinary project teams vary in configuration in terms of how they perform their work. An interdisciplinary project team may include members who each have expertise in a different area—i.e., the diversity of disciplines is “interpersonal” at the team level [64]—or include members who each have experience in all the different aspects present in the team—i.e., the interdisciplinarity is “interpersonal”. In addition, interdisciplinary teams may be dispersed or partially dispersed, come from one or more organizations, or cooperate within one organization or with many external institutions [65].

2.4. Challenges of Interdisciplinary Work

Interdisciplinary teams try to integrate their diverse knowledge so that their collective knowledge is greater than the sum of the knowledge of individual members [66,67]. This provides better-quality problem solving and a broader view of the analyzed problem [68]. On the other hand, the researchers in [69–71] emphasize that the integration of knowledge of team members, especially in situations novel to Industry 4.0 projects, is a challenge. In this context, ref. [72] believes that interdisciplinary projects can be more complex and require more bureaucracy or other efforts to organize and coordinate individual contributions. Others researchers, e.g., ref. [72,73], emphasize members of interdisciplinary teams speak different “languages”, which influences the direct cooperation in these teams, creates reasons for conflict and makes them tend to share tasks more strongly. In addition, the literature, e.g., ref. [51,74], points out the difficulty of integrating the various knowledge bases of interdisciplinary teams, emphasizing that closer interaction between team

members is necessary. Ref. [75] stresses that “interdisciplinarity requires more than just complementarity”, it requires “new types of empirical approaches” as well as “integrated analyses”. Similarly, ref. [76] points to the importance of close communication and cooperation between team members in interdisciplinary projects. They argue that frequent direct interactions facilitate knowledge integration but also contribute to building trust and common understanding of the research problem, which improves the quality of results and reduces coordination costs over time. In this context, ref. [77] identified five practices that project teams can use to integrate their knowledge to cocreate a solution. Moreover, the researchers confirm the key role of active communication in the process of knowledge transformation and integration, especially when the tasks are of innovative nature, i.e., as it is the case with projects implemented at the intersection of different disciplines and in the area of Sustainable Industry 4.0.

Refs. [78,79] emphasize that the more diverse the disciplines are, as presented by team members with little common experience, the greater the differences between their tasks may be. Each team member, who represents a different specialization of knowledge, comes to the team with a different “world of thought” and understands problems, critical elements and problem-solving steps differently than other team members [77,80]. Therefore, it is important that each interdisciplinary team includes leaders who, through their integration skills, will support interaction and discussion between team members to generate the trust and common understanding necessary for knowledge integration [81].

Ref. [82] treats team-leader behavior as the key input that shapes the knowledge development process, and suggests that this behavior is key to ensuring that the unique knowledge of team members can be used by the entire interdisciplinary team. Ref. [83] points out that coordination in interdisciplinary teams can be improved if the team uses members’ individual leadership strengths. This is also emphasized by [84], emphasizing that interdisciplinary projects can increase the probability of scientific breakthroughs by bringing together ideas, tools and specialists from different research and practice areas. Moreover, the importance of leadership is also emphasized for projects in Sustainable Industry 4.0 and referred to as Leadership 4.0 [85,86]. Ref. [87] emphasizes that implementing Leadership 4.0 requires investment and openness to cultural change. Leadership 4.0 styles must be open, leading to a learning- and innovation-oriented culture focused on improving and integrating knowledge and thinking outside the box [88]. Ref. [89] indicates that in order to improve coordination in interdisciplinary teams, it is appropriate to adopt a common leadership structure focused on the team. Ref. [84] indicates that an integrative approach to team leadership is necessary for successful interdisciplinary projects. The goal of integrative leadership is to achieve team creativity through a process of integrating the experiences, perspectives and ideas of both team leaders and their members [90,91]. Leadership is, therefore, another element that influences the effective cooperation of an interdisciplinary Sustainable Industry 4.0 project team.

According to the analysis, the challenges related to the work of interdisciplinary Sustainable Industry 4.0 project teams involve many aspects. The most frequently stressed is the need to agree on a “common language”, close coordination of individual parts of the project, and communication and cooperation between team members. Moreover, leadership and selection of a team with specific competencies is indicated as an important factor for the success of such projects. However, from the results of the conducted analyses and what has already been emphasized, it is difficult to find in the literature research that would treat the issue of interdisciplinary competencies of project teams solving problems for Sustainable Industry 4.0 as a whole, and to indicate the competencies of members and leaders of such teams. Therefore, the research questions referred to in this article are: (1) What requirements and opportunities are set before members of project teams undertaking interdisciplinary Sustainable Industry 4.0 work? and, therefore (2) What are the competencies of members of such teams and their leaders to meet these requirements and take advantage of the opportunities for such cooperation?

3. Materials and Methods

Due to the lack of previous systematic research on the competencies of members of project teams carrying out interdisciplinary projects in Sustainable Industry 4.0, we decided to conduct an exploratory case study among members of interdisciplinary teams at one of the leading technical universities in Poland. The case study is a valuable research project in exploratory research because it is possible to obtain extensive data that allows researchers to investigate specific managerial problems in existing application areas, which extends the existing state of research [92,93]. In addition, case studies have been successfully used elsewhere to identify necessary competencies [94], including studies dedicated to Sustainable Industry 4.0 [95].

Qualitative data came from many sources: interviews, internal documentation on analyzed projects and reflective notes of project managers. In order to establish the reliability of the analysis, the sources used were triangulated [96,97].

The study started with finding a representative sample [92,93]. Subsequently, the interviews were conducted, which were partially structured and consisted of guidelines representing the research questions posed in the article. The interviews were conducted in person. Each of the interviews lasted between 30 and 60 min, depending on the respondent's statements. With the consent of the interviewees, the interviews were recorded and then transcribed from audio files to text. In addition, internal documentation of the analyzed projects provided by the technical university was used as a secondary source for triangulation [92,98,99]. All the collected data were arranged in a spreadsheet, and qualitative analysis of their content was performed [100]. During qualitative content analysis, requirements and perspectives were defined in an inductive way according to the description of [101,102] and adjusted to existing research, enabling the emergence of new knowledge [103]. The coding process started by "plunging" into the data by repeatedly reading interview transcripts to achieve a high level of data knowledge. Then, an initial code list related to the perspectives and challenges of 4.0 teams was generated and organized. In the next step, these codes were used to search for emerging categories by frequency analysis [104]. Subsequently, categories were refined by further searching for data that supported or rejected the proposed categories and the links between overlapping categories. The categories were then checked for consistency and compared to obtain reliability between encoders [104]. In compliance with high-quality research practice, the analysis was performed by a research team that included an "internal" researcher who collected the data and an "external" researcher who remained independent of the project. This approach is used extensively in psychology and social science research to provide different perspectives of data. The data were analyzed by both researchers, and disputes were resolved through discussion, ensuring a high level of agreement between the evaluators and the collected data. In the last stage, competencies corresponding to the previously identified requirements and perspectives were defined. In this process, competencies corresponding to the challenges and perspectives identified in the first stage of coding were systematically identified and improved. Then, the competencies were divided into two categories: team members and the team leader. Then, the relationships between the identified competencies and the previously identified challenges and perspectives were analyzed; in the next step, the main competencies were summarized. In order to triangulate, additional notes from project managers were used, and all 50 respondents and a focus group were interviewed to reach agreement on the identified competencies.

For the case study, one of the leading technical universities in Poland—which carries out large-scale interdisciplinary projects corresponding to Sustainable Industry 4.0 needs—was selected. The analyzed projects were undertaken as part of the "Silesian University of Technology as a Center for Modern Education based on research and innovation" project, co-financed by the European Union. The implemented projects corresponded to topics reported by employers, in particular, regional enterprises and socio-economic institutions leading in the field of Sustainable Industry 4.0 and were of significant importance for the development of these enterprises and/or the development of the region itself. The projects

were of research and development nature and included interdisciplinary issues from various disciplines (materials engineering, environmental engineering, biomedical engineering, computer science, construction, architecture, medicine, automation, mechanics and machine construction). For the implementation of each project, interdisciplinary teams were established, the work of which was managed by one main tutor and two auxiliary tutors. In addition, each project was supported by industry experts with competencies relevant to the project or experts from the University with documented scientific achievements in a given field. The projects were supported by industry experts, and the projects were derived from real problems reported by Sustainable Industry 4.0 organizations, which validates the teams as participating in Sustainable Industry 4.0 projects and makes the results applicable to other Sustainable Industry 4.0 challenges. Fifty respondents (17 women and 33 men) took part in the study. Each of the respondents came from a different project with varied interdisciplinarity. The analyzed projects included both (1) teams in which members each had expertise in a given area, and the project dealt with problems at the crossroads of at least two areas, and (2) teams where only a single member had expertise in a given area, and the project dealt with issues from several areas.

Respondents were randomly selected to participate in the study in order to generate generalizable results with the least possible burden. Freedom of speech and anonymity were ensured during the research in order to obtain the most reliable answers. Thanks to the advanced implementation of Sustainable Industry 4.0 in the analyzed entity, the obtained results may provide good practices for building teams executing interdisciplinary Sustainable Industry 4.0 projects.

4. Results

When asked about the challenges and perspectives of working in interdisciplinary project teams implementing Sustainable Industry 4.0 solutions, the respondents pointed out numerous problems they faced, but they also highlighted opportunities this work entailed. Table 1 presents perspectives and challenges defined by the 50 respondents, along with the frequency of individual indications.

As seen in Table 1, the biggest challenges for the respondents were: coordination of the project and its individual parts (32 out of 50 respondents), integrative team leadership (27 out of 50 respondents), establishing a common language among specialists from different disciplines (27 out of 50 respondents) and building a team consisting of specialists with competencies required for the project (21 out of 50 respondents). Regarding perspectives of working in an interdisciplinary Sustainable Industry 4.0 team, the respondents particularly pointed out the possibility of obtaining better results (26 out of 50 respondents) thanks to synergy, a wide view of the project (28 out of 50 respondents), proper division of competencies, which allowed individual team members to focus on the areas of the project that were best known to them (25 out of 50 respondents) and mutual learning in the team (23 out of 50 respondents). For the next part of the study, the results of repeated interviews with the 50 respondents were used to define competence requirements for members of interdisciplinary Sustainable Industry 4.0 teams. Due to the fact that the interviews clearly emphasized the role of the leader(s) in project management, the research results (Figure 1) defined common competencies for the project team and additional competencies for the leader(s).

The description of these competencies is presented in Table 2.

As seen in Table 2 and Figure 1, the study identified a total of 15 competencies necessary to implement interdisciplinary Industry 4.0 projects. Among these 15 competencies, 9 (strategic perspective, communication skills, readiness to compromise, creativity, digital skills, ability to learn actively, ability to listen actively, conscientiousness and persuasion) are dedicated to the entire project team, while 6 (ability to coordinate work, conflict resolution, decision making, motivation, empowering and resource management) are assigned only to the leader(s). Table 3 shows the links between the defined competencies (Table 2) and the requirements and perspectives identified at an earlier stage (Table 1).

Table 1. Challenges and perspectives for interdisciplinary project teams implementing Sustainable Industry 4.0 solutions.

ID	Challenges	Number of Indications	ID	Perspectives	Number of Indications
W1	coordination of the project as a whole and the need to coordinate different parts of the project	32	P1	a comprehensive view of the project problem/product	28
W2	establishing a leader to integrate the project and share leadership within the team	27	P2	higher quality of the solution received	26
W3	different “language” presented by specialists from different disciplines	27	P3	effective use of the competencies held by individual team members—everyone is competent in what they do	25
W4	building a team with all the competencies required in the project, including digital competencies	21	P4	mutual learning in a team, drawing on the experience and knowledge of other specialists	23
W5	more time for the right communication flow	18	P5	the ability to solve more complex problems	22
W6	lack of possibility of mutual assistance in issues known only by individual team members	13	P6	the ability to solve innovative problems	20
W7	more time for the team to adjust to each other	12	P7	greater creativity	19
W8	rigid time frame	11	P8	the general knowledge of related disciplines acquired by the team members	16
W9	conflicts arising from a different perceptions of the problem	11			
W10	frequent changes in projects caused by unpredictable events related to the requirements of given disciplines and the emergence of new technological solutions	9	P9	shared responsibility for the outcome of the project, which contributes to greater involvement of the entire team	14

Source: own study based on the conducted research.

As can be seen in Table 3, all of the defined competencies are related to the challenges and perspectives of working in Sustainable Industry 4.0 interdisciplinary teams. Competencies dedicated to project team members slightly favor perspectives related to the implementation of analyzed projects than to cope with challenges, while the additional competencies identified for the project leader are slightly more focused on diagnosing challenges than understanding perspectives. Moreover, as shown in Table 3, most of the links between perspectives and requirements for project team competencies can be seen in relation to strategic perspective, communication skills and persuasion, while for leaders, competencies relate to work coordination, resource management, empowering and motivation.

The obtained results, as one of the first studies, present the competencies of team members and their leaders, combining the competencies necessary for Sustainable Industry 4.0 and their interdisciplinary context, thus identifying the interdisciplinary competencies of project teams and their leaders necessary for Sustainable Industry 4.0. Earlier studies in this area referred to the analyzed areas separately, not allowing for a holistic approach to this issue. What is more, unlike previous studies, this study highlights important

competencies in the analyzed areas, not only regarding the project manager himself, but also in relation to team members, which makes the results useful for HR managers who are searching for Sustainable Industry 4.0 employees as well as for project managers.

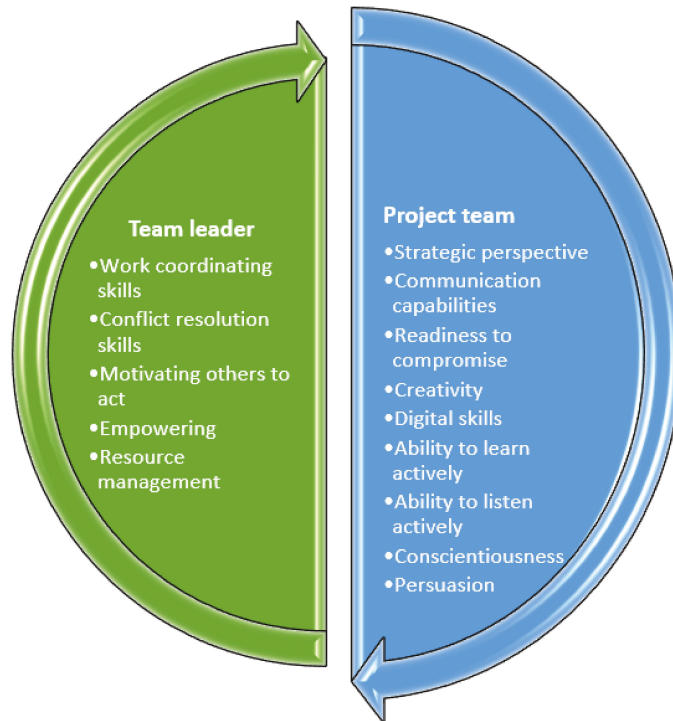


Figure 1. Competencies of interdisciplinary Sustainable Industry 4.0 teams.

Table 2. Description of competencies of interdisciplinary Sustainable Industry 4.0 teams.

ID	Competencies	Characteristics
SP	Strategic perspective	Provides a comprehensive view of the problems solved and considers the consequences of solving them in the short and long term.
CC	Communication capabilities	Active communication between all people involved, tailored to the requirements of each member. It also means being accessible to other team members and being able to communicate in a digital environment.
RC	Readiness to compromise	Enables working on the principles of cooperation and collaboration. It allows accepting different ideas, searching for a common solution to the problem and understanding interpersonal relations.
C	Creativity	Enables the use of different skills and knowledge, from different perspectives and worldviews of project team members to achieve a common solution. It allows going beyond one’s own thinking patterns and to operate efficiently at the crossroads of different fields and disciplines.
DS	Digital skills	The ability to communicate and use information and data and to use digital technologies to solve problems and think critically. Building a learning environment in which new technologies are used in proposed solutions and for teamwork.

Table 2. Cont.

ID	Competencies	Characteristics
LA	Ability to learn actively	A willingness to experiment in order to learn and to innovate using knowledge from different disciplines and different technologies, guided by the digital way of thinking.
ALA	Ability to listen actively	Focus on cooperation in a culture of feedback, and openness to suggestions and ideas from team members outside their discipline
CN	Conscientiousness	A clear commitment to the direction one is working in, and to encourage other team members to support the direction chosen. It supports timely completion of tasks and cooperation at every stage of the project.
PR	Persuasion	Building a learning and innovation environment that enables presentation of an approach to other team members to encourage them to change their point of view, while understanding the position of other team members, recognizing the need to listen to that position and indicating the rationale for a change in approach
		Team leader
WC	Work coordinating skills	Enables coordination of the different parts of the project as a whole and directing the work of the project team members in such a way that together they achieve the desired result
CR	Conflict resolution skills	Eliminates, reduces and weakens conflict among team members, or gives it a certain direction in order to use its positive and creative features and thus achieve a better-quality solution
MD	Ability to make decisions	The ability to gather relevant information from a wide range of sources (including consideration of the challenges of using new, beneficial technologies) and, on this basis, make the right decisions
MO	Motivating others to act	The ability to influence (without using power) team members to stimulate them to achieve their goals, and to support them in their efforts
EM	Empowering	Involving team members in the decision-making process and engaging them in digital environments. Enables the creation of a participatory culture based on trust and cooperation, a sense of belonging and active participation.
RM	Resource management	Ability to organize work in a team and assign responsibilities in accordance with the competencies and personal characteristics of team members, and to monitor the effectiveness of teamwork

Source: own study based on the conducted research.

Table 3. Linking the defined competencies to the identified challenges and perspectives related to working in interdisciplinary Sustainable Industry 4.0 teams.

Competencies/ Challenges and Perspectives	Strategic Perspective	Communications Skills	Readiness to Compromise	Creativity	Digital Skills	Active Learning	Active Listening	Conscientiousness	Persuasion	Work Coordinating Skills	Conflict Resolution Skills	Decision Making	Motivation	Empowering	Resource Management
coordination of the project		+								+					
appointing a leader										+	+	+	+	+	+

Table 3. Cont.

Competencies/ Challenges and Perspectives	Strategic Perspective	Communications Skills	Readiness to Compromise	Creativity	Digital Skills	Active Learning	Active Listening	Conscientiousness	Persuasion	Work Coordinating Skills	Conflict Resolution Skills	Decision Making	Motivation	Empowering	Resource Management
different language	+	+	+				+		+		+				
required competencies of a team										+			+		+
more time for communication		+	+							+			+	+	
lack of possibility of mutual assistance								+	+						
more time to adjust to each other		+	+										+	+	
rigid time frame								+							
conflicts		+							+		+	+			
frequent changes	+				+							+			
a comprehensive view of the problem	+	+													
higher-quality results				+	+	+	+			+					+
effective use of individual competencies		+							+				+		+
mutual learning in a team		+				+								+	
ability to solve complex problems	+			+	+						+				+
ability to solve innovative problems	+	+		+	+	+	+								+
greater creativity	+			+		+	+			+					
general knowledge of the related disciplines	+					+	+								
shared responsibility for the results		+						+					+		

Source: own study based on the conducted research.

5. Discussion

The article poses two research questions. The first concerned requirements and opportunities connected with interdisciplinary Sustainable Industry 4.0 work, and the second concerned competencies of such team members and their leaders.

Answering the questions related to requirements and opportunities of such work, it was found that, in the studied projects, the biggest challenges were coordination of the project and combining its individual parts, integrative team leadership, establishing a common language among specialists from different disciplines and building a team, while perspectives connected with such work included the possibility of obtaining better results thanks to synergy, a wide view of the project, proper division of competencies and mutual learning in the team.

Answering the second research questions, related to competencies of interdisciplinary Sustainable Industry 4.0 teams, it was found that 15 competencies are necessary, and, among these 15 competencies, 9 are dedicated to the entire project team (strategic perspective,

communication skills, readiness to compromise, creativity, digital skills, ability to learn actively, ability to listen actively, conscientiousness and persuasion), while 6 are assigned only to the leader(s) (ability to coordinate work, conflict resolution, decision making, motivation, empowering and resource management).

The considerations presented in the article allow a deeper understanding of the specificity of work in Sustainable Industry 4.0 teams. When analyzing the characteristics of Sustainable Industry 4.0 work and the requirements set here for various groups of professions, it can be concluded that the 4th Industrial Revolution has unequivocally transformed the business sector around the world. This is shown in various studies [105,106], which emphasize that, in order to ensure a successful transition to Sustainable Industry 4.0, it will be necessary to change the management paradigm and apply a new approach to teaching and improving the individual competencies of employees. Although research in the field of Sustainable Industry 4.0 uses different levels of analysis to explain the changes brought about by the new fourth era of digitization and their impact on the development of the labor market and the technologies themselves, as many authors point out [38], the literature lacks an analysis of the impact of the sustainable 4.0 paradigm on employees. Some of the few publications that pay attention to this aspect are the studies by [53,107,108], in which the authors emphasize that Sustainable Industry 4.0 poses challenges in the social sphere, requiring companies to develop the highest level of competence of their specialists and attract new talent able to deal with the increased complexity of new technologies.

As the analysis shows, the changes caused by the new 4.0 paradigm are also reflected in the higher requirements for project team members, which are indicated as an important element of Sustainable Industry 4.0. This is also associated with a change in the approach to 4.0 project management itself, which, in this case, is more complex, innovative, burdened with a higher level of risk and requires the cooperation of highly specialized employees from various disciplines, often supported by employees from their economic–social environment. This is consistent with previous analyses in this area [22,109] that emphasize that Sustainable Industry 4.0 will bring radical changes in relation to project management. For example, refs. [22] points out that traditional project management styles must be changed in order to adapt to the 4th Industrialization Revolution with many variations, and that there are many challenges connected with project managers in Sustainable Industry 4.0, as it is certain that a project manager must have improved soft and hard skills to implement complex, autonomous and sustainable Industry 4.0 projects.

One of the key aspects of cooperation in 4.0 teams is their interdisciplinary nature due to the fact that interdisciplinarity is strongly related to innovation [110]—which is an inseparable element of Sustainable Industry 4.0—and due to the increasing complexity of projects and tasks faced by modern employees [111]. The requirement of interdisciplinarity of projects implemented for Sustainable Industry 4.0 is also emphasized in publications by other researchers. Refs. [112,113] indicate that complex problems cannot be solved within one discipline, and employees, including team members, require appropriate personal and social skills, defined as interdisciplinary competencies, in the era of the modern 4.0 economy. Among these competencies, the authors mention: solving complex problems in various disciplines, communication between disciplines, handling interdisciplinary cooperation and teamwork, and using integration potential to create innovation. Similar conclusions were obtained in this study, which shows that the most important challenges and perspectives related to the work of such teams includes coordination of individual parts of the project, communication between members from different disciplines, and a broad view of the problems raised in the project. This is also in line with other research, where attention was paid to difficulties in integrating the different parts of the project e.g., ref. [50] or problems in going beyond their knowledge disciplines, e.g., ref. [77].

Moreover, leadership is extremely important in the context of the analyzed subject matter, as it enables effective teamwork. Contemporary research in this area highlights the role of inclusive leadership, which is linked to the concept of shared leadership, as also noted in this research. As [114,115] point out, the project team also has an inclusive role,

which is to fill knowledge gaps by providing people with the right competencies to the team at different stages of the project. That is why it is so important that team members are entitled to use their competencies effectively in developing a project solution and to take on leadership roles if necessary [116]. This is consistent with research, e.g., ref. [88] conducted in the area of Sustainable Industry 4.0, which stresses that if leadership is more collaborative, participatory and decentralized, people feel more encouraged to make decisions and experiment to create an agile and responsive network culture.

According to the results of the research, the members of teams should mainly have competencies such as: strategic perspective, communication skills, willingness to compromise, creativity, digital skills, ability to learn actively, ability to listen actively, conscientiousness and persuasion. This is confirmed by previous reports that indicate that there should be an important soft component to manage (and face) the introduction of new technologies [39], and so-called soft skills are increasingly important in the current digital age, and can constitute its key element as competences resistant to changes [38,41].

In light of the conducted research, it was also revealed that the project manager plays a key role in the digitization process. Due to changes in work methods and the challenges facing Sustainable Industry 4.0, changes and challenges are also faced by project managers. Key competencies identified for the 4.0 project leadership role were highlighted: ability to coordinate work, conflict resolution, decision making, motivation, empowering and resource management. This is consistent with other research on 4.0 project leader competencies. This is also confirmed by [7], which indicates that the most significant changes related to the requirements of Sustainable Industry 4.0 project managers are communication style, interaction, speed and ability to work, and basic knowledge. They also add that the project manager must have improved soft and hard skills to implement complex and autonomous Industry 4.0 projects, and that the competencies related to Sustainable Industry 4.0 go beyond those defined by PMI or IPMA for the role of project manager.

The main limitation of this study is, by definition, a limited research method. Therefore, it is necessary to repeat this study in different contexts, in organizations of different sizes and types of projects, and in different countries. While our qualitative method allowed for an in-depth examination of the context, it also, to some extent, limits the reliability of the findings. By incorporating quantitative methods and replicating this study with either a quantitative or blended method, future research can further enhance the reliability of these findings. For example, quantitative research can be conducted to analyze the relationship between the identified competencies of interdisciplinary Industrial 4.0 project teams and the success of these projects. Moreover, some of the identified challenges and opportunities related to interdisciplinary Sustainable Industry 4.0 work may also apply to other areas. Therefore, future research could shed more light on the clear challenges and perspectives related to interdisciplinary Sustainable Industry 4.0 work, as some of them may relate to overall organizational transformation. Moreover, it is also worth considering how the competencies of such teams in other countries and cultures are developed, as the project environment is expected to have a significant impact on the competence requirements of the analyzed teams. A comparative analysis of competencies of teams implementing single-area Sustainable Industry 4.0 projects with the results obtained would also be cognitively interesting. This would indicate whether team cooperation influences the competencies required to a large extent. One limitation is also that 50 individuals spoke from the perspective of 50 teams, so individual's findings were confounded by their teams. Therefore, it is not possible to conclusively state whether the obtained results represent individual idiosyncrasies or team differences. Therefore, in future research, the target group can be expanded to include multiple members of a given team to get a more complete picture of the differences between teams.

6. Conclusions

The obtained results, as one of the first studies on this topic, present the competencies of team members and their leaders, combining the competencies necessary for Sustainable

Industry 4.0 and their interdisciplinary projects, thus identifying the interdisciplinary competencies of project teams and their leaders necessary for Sustainable Industry 4.0. Earlier studies of this topic referred to the analyzed areas separately, not allowing a holistic approach to this issue. What is more, unlike previous studies, this study highlights important competencies in the analyzed areas, not only in relation to the project manager himself, but also in relation to team members, which makes the obtained results useful for HR managers who are searching for Sustainable Industry 4.0 employees as well as for project managers.

This article is a contribution to the literature on management in the area of team competency management and from the perspective of organizations implementing sustainable 4.0 projects, thus extending the theory of human resource management to Sustainable Industry 4.0 and developing the argument for a greater focus on improving the soft skills of employees, in particular on developing their interdisciplinary skills. In practice, the article responds to the needs of companies and educational institutions (e.g., universities and colleges) to reflect on the desired competencies of employees—including, in particular, members of project teams implementing Sustainable Industry 4.0. projects—to cope with upcoming industry and sectoral changes. Hence, the obtained results are the basis for identifying the following recommendations for future teams implementing similar projects:

1. Awareness by the organization that Sustainable Industry 4.0 projects require interdisciplinary project teams and often also additional external support. Project team members can come from areas directly and indirectly related to the project topic. In this context, it is important to create organizational opportunities for cooperation within such teams.
2. Making the organization's management aware of important competencies necessary to implement interdisciplinary Sustainable Industry 4.0 projects.
3. Taking into account that project management 4.0 very often requires a transition from a classic to an agile approach to project management, which is the basis for innovation and customer satisfaction.
4. The need for an integrative approach to team leadership by the project manager, aimed at supporting an agile environment,
5. Taking into account whether the proposed project management frameworks allow for the additional time and communication costs required for the successful implementation of interdisciplinary 4.0 projects.

The study also contributes to the knowledge base concerning project management in the area of individual competence development of project team members and the management of interdisciplinary and sustainable 4.0 projects, indicating that the modern 4th Industrial Revolution requires a new, more flexible and agile approach to project management and new competencies of team members, including, in particular, the project manager. Thus, the obtained results will allow for more thoughtful team selection and, consequently, for greater effectiveness of the implemented projects.

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Article

Driving Sustainable Innovation in New Ventures: A Study Based on the fsQCA Approach

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Abstract: With the external environment becoming increasingly complex and changeable, how we can effectively enhance the innovation of companies in sustainability has become the focus of research. For startups, due to their lack of resources and poor independent innovation capabilities, they need to search for external knowledge from outside to meet their own needs. Therefore, obtaining external knowledge sources and adopting appropriate methods for knowledge search is the key to affecting innovation in sustainability. Moreover, enterprise capability is also an important factor restricting sustainable innovation. In this paper, we construct an integrated framework of resources and capabilities based on theoretical learning and practice between 2018 and 2021, containing technical knowledge, market knowledge, a formal search, an informal search, organizational learning, and strategic flexibility. Taking 450 new ventures in China as the research sample, we adopt the fsQCA method and derive the path driving the sustainable innovation of new ventures. The results show that resources and enterprise capabilities combine to influence sustainable innovation, and there are two configuration paths driving the sustainable innovation of new ventures. In the first pathway, a technical knowledge search, a market knowledge search, organizational learning and strategic flexibility are the core conditions; in the second pathway, a formal search, an informal search, organizational learning, and strategic flexibility are the core conditions.

Keywords: sustainable innovation; knowledge search; organizational learning; strategic flexibility; new ventures; QCA

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1. Introduction

With the COVID-19 pandemic sweeping across the globe, it has become increasingly difficult for companies to maintain sustainable innovation, and startups are the first to bear the brunt. Enterprise innovation in sustainability refers to continuously obtaining technical and market information, launching innovative products or service projects, and constantly obtaining economic, environmental, and social benefits [1]. By exploring innovation in sustainability, they can create dual value of economic and social sustainability [2]. Moreover, sustainable innovation also provides a new source for the sustainable development of enterprises [3]. Therefore, it is of great significance to explore what the important factors are in driving sustainable innovation and how to maintain sustainable innovation in new ventures. Given the lack of research on the integration of resources and capabilities [4–6], this paper attempts to select appropriate variables in terms of resources and capabilities, trying to explore how they work together to influence sustainable innovation. With the increasing complexity of technology, rising R&D costs, accelerating knowledge growth and diffusion, and shortening product life cycles, the external knowledge search has become the most important factor affecting sustainable innovation of enterprises [7–9]. Dynamic capabilities theory tells us that enterprises can rationally integrate and allocate resources through “enterprise capabilities” and should be able to cope with the external uncertain environments [4,10]. Organizational learning is the course of absorbing and processing new

knowledge [11], and it involves the recognition, screening, integration, and transformation of knowledge [12]. As one of the most important capabilities of an enterprise, it can provide a core competitive advantage [13]. However, for startups, due to their short establishment time and insufficient experience, they have not yet formed mature learning practices, and so it is not appropriate to apply traditional organizational learning theories. Therefore, it is necessary to explore the inner learning mode of new ventures and its effects on their sustainable innovation. Strategic flexibility is the special organizational ability of enterprises to react to changes in the external environment by reallocating organizational resources, processes, and management activities [14,15]. Enterprises with higher strategic flexibility can reduce their reaction time to environmental changes, and can redeploy resources more effectively, thereby increasing the value of innovative resources [15,16]. Therefore, strategic flexibility can effectively enhance the sustainable innovation of enterprises.

Following the study of Sofka and Grimpe [17] and Guo B and Guo JJ [18] concerning what to search for and how to search, this paper adds two capability variables and constructs an integrated framework of resources and capabilities. DZ Auto Equipment Manufacturing Company is a high-tech intelligent equipment manufacturing enterprise specializing in a robotic automatic welding production line, electrical automation, and robot application. During the survey, it was found that conducting external knowledge search activities and having better organizational learning and strategic flexibility are the keys to sustainable innovation. First, they obtained automation-related technologies and parts processing production lines from suppliers through search methods such as technology purchases and technology licenses, and obtained the core technologies of enterprise production; secondly, they cooperated with Jilin University, Chinese Academy of Sciences and other units to continuously learn new knowledge and upgrade core technologies to improve their own competitive advantages; finally, they were able to flexibly integrate and allocate resources within the enterprise, and respond quickly to changes in the external environment, which is also the key to maintaining competitiveness during the COVID-19 pandemic.

Indeed, sustainable innovation is a necessary condition for the application of new knowledge and can improve organizational learning capabilities while promoting economic growth of enterprises [19,20]. Therefore, sustainable innovation is the result of the combined effect of enterprise resources and capabilities.

Through a literature review, it is found that the following two aspects are mainly studied with regard to knowledge search. The first is the impact of knowledge search on innovation [21–23], while the second is the mechanism of knowledge search on innovation from different perspectives, such as the knowledge integration perspective [24,25], the absorptive capacity perspective [26–28], etc. Most studies used the dimensions of search width and depth, which cannot solve the problem of what knowledge enterprises search for and how to search for knowledge. To address this problem, we take a two-dimensional partitioning approach in our study for knowledge search. The search content (knowledge source) is divided into a technical knowledge search and market knowledge search, and the search method is divided into a formal search and an informal search.

In addition, most of the existing literature used regression empirical research methods to explore the relationship between resources and capabilities and enterprise sustainable innovation. However, this study method can only solve the marginal effect between variables and cannot solve the complex multivariate interaction [29]. Therefore, we take configuration as the study perspective, adopting the fuzzy set qualitative comparative analysis approach to incorporate the content attributes and method attributes of an external knowledge search, organizational learning, and strategic flexibility into a research model. In this way, it not only examines the impact of a single variable on sustainable innovation, but also explores the interaction between variables, and derives the way to drive sustainable innovation in new ventures.

Based on the analysis of the above arguments, we construct an integrated model of resources and capability, taking 450 new ventures in China as a research sample, and

conduct empirical analysis through the fsQCA approach. The results show that there are two configuration paths driving the sustainable innovation of new ventures. In the first pathway, a technical knowledge search, market knowledge search, organizational learning, and strategic flexibility are the core conditions; in the second pathway, a formal search, an informal search, organizational learning, and strategic flexibility are the core conditions.

Therefore, this paper makes the following related theoretical contributions. Our study's first contribution is constructing an integrated framework of resources and capabilities and exploring whether they are sufficient and necessary to drive sustainable innovation.

The second contribution is that it employs emerging management research methods and presents the configuration paths that drive the sustainable innovation of startups.

The third contribution is that it divides knowledge search into technical knowledge and market knowledge according to the search content, and divides knowledge search into formal search and informal search according to the search method. It also enriches the open innovation theory and expands the research boundary of knowledge search.

The aim here, therefore, is to answer three research questions: (1) Are knowledge search, organizational learning, and strategic flexibility the main factors and necessary conditions driving sustainable innovation? (2) Under the interaction of multiple variables, do resources and capabilities jointly drive the sustainable innovation? (3) What is the configuration path to enhance sustainable innovation in new ventures?

Based on the resources–capabilities integration view, this paper explores the factors that affect innovation for sustainable business and the configuration path that drives sustainable innovation in new ventures. The following section presents relevant theories and literature reviews on knowledge search, organizational learning, and strategic flexibility, which provides theoretical and literature support for our research on sustainable innovation. Next, we propose a conceptual model that drives sustainable innovation and tests the model with the fsQCA method. The final section provides conclusions from the study, managerial implications, and suggestions for sustainable innovation research in the future.

2. Theoretical Retrospection

The open innovation theory holds that the innovation of enterprises does not only rely on internal research and development, but more and more on external knowledge. Enterprises achieve innovation through the purposeful inflow and outflow of knowledge, thereby improving their sustainable competitive advantage in the market [30]. Therefore, enterprises can acquire the new knowledge they need for themselves through external knowledge search activities [21,31].

Nevertheless, the knowledge-based view believes that knowledge is an important resource for enterprises and can provide sustainable competitive advantages [32]. Knowledge management is characterized by the implementation of knowledge strategies and processes in an organization to increase the effectiveness and efficiency [33].

In addition, the dynamic capability theory holds that, facing the complexity and uncertainty of the external environment, enterprises need to cultivate their own dynamic capabilities. Strategic flexibility is a dynamic ability to flexibly allocate resources and coordinate processes when an organization faces environmental threats. Enterprises with high strategic flexibility can use their existing resources more flexibly, thereby increasing the innovative value of resources [15,34].

2.1. Open Innovation Theory

One of the most important theoretical backgrounds of open innovation is cooperative research and development. Before the rise of cooperative R&D, most of the R&D models followed the Schumpeter style, which was called “closed innovation” by Chesbrough [30]. By the end of the 20th century, the closed innovation model was gradually replaced by open innovation, and the new innovation process became more open, decentralized, and democratic, highlighting the interactive characteristics of the innovation process. Based on the open innovation theory proposed by Chesbrough [30], modern companies can not

only integrate beneficial creative resources from within, but also carry out cooperative innovation by introducing, digesting, and absorbing external diversified resources. This makes external knowledge search activities increasingly common.

Dahlander and Gann [35] summarized four reasons why open innovation is generally accepted:

- (1) It reflects socioeconomic shifts in work patterns, with skilled workers seeking a portfolio of jobs rather than a lifetime of work;
- (2) Globalization expands the scope of the market, thereby allowing a finer division of labor;
- (3) An enhanced market system allows businesses to trade ideas;
- (4) New technologies provide cooperation and coordination across geographic distances.

The existing research on open innovation is mainly carried out from two perspectives: the process perspective and the organizational perspective. Open innovation based on the process perspective mainly takes the input and output processes of innovation as a classification dimension. Von Hippel [36] classified innovation processes and outcomes into two dimensions; Knudsen and Mortensen [37] distinguished four types of open innovation with progressive characteristics. The classification of open innovation based on organizational perspective is richer and more diverse. Keupp and Gassmann [38] redefined open innovation by benchmarking high–medium–low portfolio differences in open innovation breadth and depth across firms.

Therefore, open innovation brings more external resources to enterprises, and also brings the possibility for enterprises to search for external knowledge.

2.2. Knowledge-Based View

The resource-based theory tells us that resources should be valuable, scarce, and irreplaceable [39,40]. Therefore, knowledge is the most important strategic resource of an enterprise. Knowledge can be defined as the assessment of an individual's learning resources and knowledge that allow them to record a good performance or task and indicate their sufficiency or suitability for it [41]. The enterprise is a knowledge processing system under the condition of bounded rationality and the specialized division of labor. The types of knowledge mainly include tacit knowledge and explicit knowledge [42–44]. Explicit knowledge is that which can be directly recorded, encoded, or easily communicated and transmitted. Tacit knowledge refers to knowledge that cannot be directly or easily transferred. Tacit knowledge can only be transferred slowly through "learning by doing", so it can bring a sustainable competitive advantage to a business [45,46].

Based on the knowledge-based theory, knowledge is the most important strategic resource of an enterprise, which can be created, stored, and applied, and can contribute to the sustainable innovation. This is mainly reflected in the following four aspects:

- (1) A business is a knowledge system [47];
- (2) Knowledge is the most important strategic resource of an enterprise [48];
- (3) Companies can acquire and transform other resources by using knowledge [49];
- (4) Knowledge possessed by firms is a key factor in making differences between them [50].

It can be seen that the ability of enterprises to use knowledge is the main reason for enterprises to maintain and enhance their competitive advantages. Therefore, only through learning can an enterprise transform the new knowledge acquired from the outside into the competitiveness.

2.3. Dynamic Capability Theory

Enterprise capability is an important strategy, which comes from learning, the acquisition of external resources, and the reallocation of resources in addition to individual capabilities [51]. Makadok [52] defined capability as a special type of resource whose purpose is to increase the productivity of other resources owned by a firm; thus emphasizing the distinction between capability and resource.

According to the dynamic capability view, the term “dynamic” refers to the ability to update existing capabilities to achieve flexibility in response to changing circumstances. The term “capability” emphasizes the need for strategic management to properly adjust, integrate, and reallocate internal and external organizational resources and capabilities to adapt to changing circumstances [4,53].

There are two main research perspectives on dynamic capabilities: the cognitive perspective and the process perspective. Scholars with a cognitive perspective argue that firms with highly dynamic capabilities can identify threats and opportunities, influence external changes that align an organization with its business environment, and prevent the emergence of organizational rigidity or inertia [10,51]. Scholars who hold a process perspective view dynamic capabilities as firm practices or processes, and they see dynamic capabilities as a tool that can exist in the form of specific and identifiable processes [4].

In addition, the current background of the digital economy, open innovation, “Internet+” and the COVID-19 pandemic have endowed enterprises with new situations of dynamic capabilities, and the study of dynamic capabilities in special situations has also become a hot spot at this stage.

2.4. External Knowledge Search

As technology becomes increasingly complex, R&D costs continue to rise, and product life cycles continue to shorten, traditional “closed innovation” can no longer meet the knowledge needs of these startups. As a result, they increasingly emphasize the importance of external knowledge, and generally use external knowledge sources. By combing through the existing literature, we have found that the related research of external knowledge search mainly focuses on the following aspects: the first is the emphasis of external sources of knowledge, such as technology purchases, R&D cooperation, alliances, etc. [54,55]. The second is the emphasis of influencing factors of knowledge search, such as the network environment, previous experience, innovation objectives, etc. The third is the study of relationship between the external knowledge search and performance. For example, Wang et al. [8] took data from 187 corporate entities as a research sample, and divided knowledge search into two dimensions of search width and search depth and built a relationship model between knowledge search and organizational innovation performance. Although the research on knowledge search is increasingly rich, more research needs to be done. One reason for this is that the research boundary of knowledge search is still very vague. Some scholars believe that knowledge search is a process of searching for and acquiring knowledge from external knowledge sources. However, some scholars argue that knowledge search includes not only the acquisition process, but also the knowledge integration and creation. The second is that, in existing research, the division of knowledge search dimensions mainly adopts the research results of Laursen and Salter [21], who divided knowledge search into search width and search depth. However, the knowledge search is a complicated process. Questions such as what knowledge to search for and how to search for it need to be solved urgently. The third is that the past research objects were mainly mature enterprises. These authors believed that the relationship between knowledge search and innovation was an “inverted U-shaped” one and concluded that the search was excessive. However, due to a lack of resources, startups have a more obvious dependence on external resources, and so it is more meaningful to take startups as research objects. Based on this, our research constructs a multi-dimensional knowledge search framework, divided into technical knowledge search and market knowledge search in accordance with the search content, and divided into a formal and informal search in accordance with the search method, as is shown in Figure 1.

In future research, first, it is necessary to further explore the research boundary of external knowledge search, and build a new research perspective in the context of the new era, such as the digital economy and the COVID-19 pandemic; secondly, it is necessary to further explore issues related to external knowledge search for small and medium-sized enterprises and start-ups, as well as their differences and connections with

mature enterprises; thirdly, it is necessary to examine the influence and mechanism of the combination and balance of different dimensions of knowledge search on innovation.

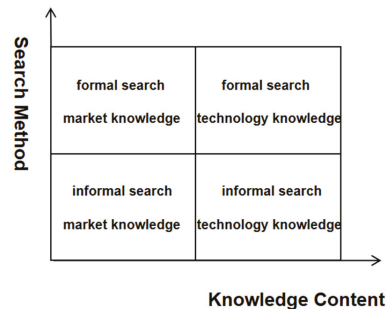


Figure 1. Knowledge search framework. Note: Figure 1 is modified and proposed by the author according to the views of Sofka and Grimpe [17] and Guo B and Guo JJ [18].

2.5. Organizational Learning

The theory of organizational learning was first put forth by Argyris and Schon, who considered it as the result of members interacting within the internal environment of the enterprise [56,57]. In accordance with earlier studies, scholars believed that organizational changes driven by management issues are the key to learning [58]. By the mid-1990s, people generally believed that various organizations could adapt to the changing environment through learning, learn from past successes or failures, and foresee and respond to upcoming threats [59,60]. Through the research on organizational learning, it was found that organizational learning generally has two research perspectives: the ability view and the process view. Scholars who hold the concept of competence believe that organizations need to respond quickly to changes in the external environment and strive to become a learning organization [61]. Scholars who hold a process view believe that organizational learning is a process of knowledge processing by an organization, including knowledge acquisition, knowledge integration, knowledge allocation and utilization, and knowledge creation [62].

However, the existing research still has some limitations. For example, in the early studies, only knowledge management processes were analyzed in intensive departments, and the acquisition, sharing, utilization, creation, and storage of knowledge were not studied as a whole framework. In addition, although the organizational learning mode and framework for large-scale enterprises are relatively mature, organizational contexts, learning approaches, and entrepreneurial roles in startups are different; therefore, the original mature theory cannot be fully applied. As a result, this article explores the internal mechanism of organizational learning by taking startups as the research object.

For startups, organizational learning is a multi-level dynamic process that integrates psychological and social processes [63]. It includes knowledge absorption and integration by members in the organization, the transfer and sharing of knowledge, the application of knowledge, the creation of knowledge, and the storage of new knowledge, as shown in Figure 2. Knowledge recognition involves screening the inflow of new knowledge and integrating it with the internal understanding of the enterprise. In this way, the enterprise can quickly identify the nature of knowledge and shorten the knowledge distance. The essence of knowledge sharing in startups is the flow of knowledge among employees and between employees and entrepreneurs. Through knowledge sharing, members of different departments can exchange knowledge, which can improve the overall knowledge level. Knowledge integration is the process of reallocating the internal knowledge of the enterprise. The integrated knowledge will have the characteristics of the actual new understanding and some differences, and this kind of knowledge bears the unique context of the organization. After identifying, sharing, and integrating knowledge, enterprises can

fully absorb the acquired new knowledge and create new knowledge. Then, the enterprises need to perform the explicit processing and storage of new knowledge to increase the firm's total amount of knowledge, and the spillover effect of knowledge can also bring new opportunities for the enterprises.

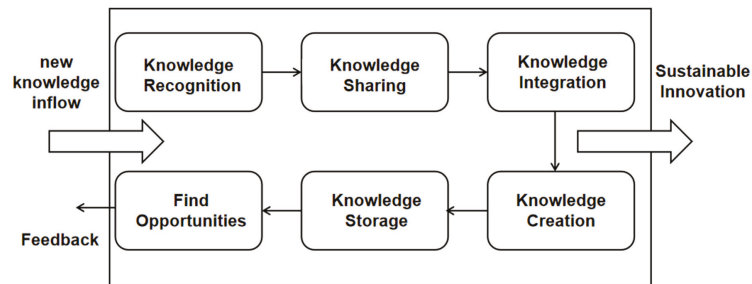


Figure 2. Internal framework of organizational learning. Note: Figure 2 is the author's point of view based on the above literature and related theories.

The first aim is to continue to explore the theoretical framework and process of organizational learning, and the main research objects are small and medium-sized enterprises and new ventures. As small and medium-sized enterprises and new ventures are more dependent on external knowledge, it is crucial for them to organize learning internally, especially with new and emerging ways of learning. The second is the division of organizational learning dimensions from various perspectives and their impact on innovation. Due to changes in the environment, learning strategies will be continuously adjusted, and the dimensions of organizational learning will be more diverse. The existing empirical research conclusions are inconsistent, and so it is necessary to continue to explore the relationship between organizational learning and innovation, especially with SMEs and new ventures as the research objects.

2.6. Strategic Flexibility

Strategic flexibility originated from the idea of "mutation management" and gradually coordinated with the resource-based view and contingency theory. In the 1980s, strategic flexibility helped in the first stage of development, emphasizing corporate strategic choices and options. At this stage, the traditional business assumptions were surpassed, and the concept and model of strategic learning were constructed. The second stage of the development of strategic flexibility was after the 1990s, reconsidered from the perspective of resources and capabilities. Compared with the previous stage, this stage originated from the fuzzy cognition of strategic flexibility. From the perspective of resources and capabilities, it explains why strategic flexibility can help enterprises deal with the threats of the external environment.

Strategic flexibility is a special organizational ability that an enterprise achieves to respond to changes in the external environment by re-allocating organizational resources, processes, and management activities [15,64]. Strategic flexibility can be proactive, for example, by sensing and adapting to changing customer needs in the market or by reacting to the emergence of new competitors [15]. Therefore, enterprises with strategic flexibility can reduce the response time to dynamic changes and can redeploy resources more effectively, thereby increasing the value of innovative resources [15,34].

However, although most studies have shown that strategic flexibility can positively impact the enterprise's competitiveness and innovation capabilities [65], the consensus on the relationship between strategic flexibility and corporate competitiveness has not been fully agreed upon, especially among small and medium-sized enterprises. The research on strategic flexibility still faces challenges and obstacles. Some scholars believe that the size of an enterprise affects the relationship between strategic flexibility and sustainable

innovation [66]. Compared with large enterprises, startups face many difficulties in fiercely competitive fields, and they are more likely to be exposed to unfamiliar environments. Some scholars believe that the impact of strategic flexibility on sustainable innovation was not significant [67], and some even came to the opposite view [68]. Therefore, the balance between the pros and cons of strategic flexibility in startups needs to be explored urgently.

3. Model

A technical knowledge search refers to the behavior of enterprises by crossing their organizational boundaries to search for and obtain knowledge related to product design, technology, and processes from outside [69,70]. Technical knowledge mainly comes from universities, scientific research institutions, suppliers, and other external enterprises. First of all, an enterprise can obtain the relevant technology needed by the technology purchasing, technology licensing, cooperative research and development, etc., which can be used to correct the technical defects of its products and improve the technical content of the enterprise. The new technical knowledge acquired by the enterprise from outside can be matched and integrated with the original knowledge to produce new knowledge to improve the innovation. Secondly, the scattered and fragmented technical knowledge acquired by the enterprise from the external network can be transformed into new knowledge to improve the level of technology [32,71]. In addition, through technical knowledge search activities, enterprises can greatly increase the knowledge reserves of their internal knowledge base, and at the same time improve their ability to allocate technical resources, which can help to better enhance their sustainable innovation.

A market knowledge search refers to the behavior of enterprises in searching for and obtaining knowledge related to product design solutions, marketing channels and business models by crossing the organizational boundaries, etc. [70]. Market knowledge mainly comes from competitors and customers in the same industry [21]. Market knowledge can also provide benefits for the sustainable innovation of startups. First of all, by establishing contact with customers, it is possible to get feedback on the performance, quality, sales status, and other factors of the enterprise's products, which is conducive to the improvement in knowledge and the increase in its market share. Secondly, the market knowledge acquired from competitors can enable enterprises to understand their own advantages and disadvantages, so as to develop choices and strategies for future knowledge acquisition. Finally, obtaining a large amount of market information through market research, information feedback, etc., can enable enterprises to fully realize market the situation of market complementary products and substitutes, and promote knowledge overflow.

A formal knowledge search refers to the behavior of establishing formal contact with external organizations and acquiring knowledge through contracts, agreements, etc., such as technology purchasing, technology licensing, R&D cooperation, technology alliances, etc. [18]. A formal knowledge search will affect the enterprise's sustainable innovation according to the following aspects: first, through a formal knowledge search, the enterprise's explicit knowledge will be increased, which will help improve the enterprise's knowledge stock and absorptive capacity. Second, establishing an excellent formal relationship with external organizations can increase mutual trust between organizations, establish a mutual learning mechanism, and reduce costs in subsequent searches [72].

Informal knowledge search refers to the behavior of acquiring knowledge through informal communication, exchanges, etc., such as private meetings, conversations, informal employment, reverse engineering, etc. [70]. Informal knowledge search will affect the sustainable innovation of enterprises according to the following aspects: First, employees of an enterprise can establish "weak relationships" by interacting with customers, suppliers, or competitors through private communication and other methods. By establishing this "weak relationship", the breadth of the knowledge search can be increased, thereby obtaining more required knowledge and saving costs. Second, through an informal search, it is more conducive for employees to understand tacit knowledge. Since tacit knowledge is less likely

to be imitated by other competitors, it makes enterprises more conducive to maintaining a sustainable competitive advantage.

It is obvious that knowledge resources constitute the most important part of organizational learning [73], which combines personal judgment, values, abilities, know-how, and technology [74]. Knowledge management is characterized by the implementation of knowledge strategies and processes in the organization to improve the effectiveness and efficiency of business processes and to maintain organizational innovation [60]. Therefore, an organization can provide itself with a core competitive advantage through various knowledge activities. First, personal learning can improve professional skills and practical experience. Entrepreneurs are the core leadership of startups. They can constantly imitate and reflect through learning methods such as experiential learning and cognitive learning, which can reduce the risk of the enterprise in its growth process, they can promote the formation of the enterprise's future innovation strategy, and they can continue to carrying out opportunity identification and utilization. Second, organizational learning can promote the transfer and sharing of knowledge. Organizational decision making, leadership, problem-solving speed, and innovation ability are all improved by spreading knowledge across the parties [75]. Finally, new knowledge can be created through organizational learning. Knowledge creation is characterized by cultivating new abilities and expertise within the organization [76]. Startups can effectively maintain their competitive advantage by producing new knowledge and improving innovation capabilities.

Strategic flexibility reflects the ability of enterprises to flexibly use and allocate resources in response to environmental changes [15]. In today's rapidly changing environment, enterprises need to be able to quickly invest resources and use them freely when responding to changes—that is, to have strategic flexibility [77]. Strategic flexibility allows firms to easily devote resources to different products, regroup resources for production, redefine products and markets, reallocate resources to support new product strategies, etc. [15]. Therefore, the improvement in strategic flexibility can provide sustainable competitive advantages and innovation [78,79]. This is mainly reflected in the following two aspects: First, through the flexible allocation and use of resources, strategic flexibility can meet the needs of innovation for resources, so that enterprises can change key elements or the structure connecting these elements, and then carry out innovation activities [80,81]. Second, strategic flexibility enables enterprises to flexibly allocate and utilize resources and can motivate enterprises to innovate in order to realize the value of internal resource endowments [15].

In summary, this research adopts the open innovation theory and the dynamic capability theory. It takes configuration as the research perspective to construct a framework for the effects of external knowledge search, organizational learning, and strategic flexibility on sustainable innovation in new ventures. The specific model is shown in Figure 3.

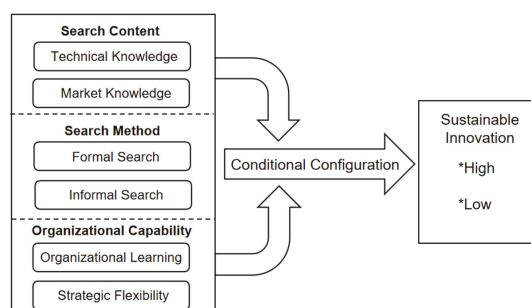


Figure 3. Causal configuration analysis model. Note: The author proposes this model based on the above literature and theory; “*High” represents the promotion of Sustainable Innovation; “*Low” represents a reduction of Sustainable Innovation.

4. Data and Methods

4.1. Research Methods

Charles Ragin first proposed qualitative comparative analysis (QCA). It is a research method between qualitative case analysis and quantitative statistical analysis and has the advantages of both [82]. Its main idea is to apply set theory and Boolean algebra to discuss the influence of conditional variables on result variables under configuration matching. Since this method is not limited by sample size, it was first applied to the field of sociology and political science [83]. When Fiss published an article on the feasibility of QCA in organizational strategy in the “Academy of Management Review” in 2007, the QCA method was brought into the field of management. Now, with the continuous optimization of this method, it has become an important tool for research in various management fields [84]. FsQCA is a more recent and extended version of the QCA that may be used for contextual analysis, which investigates how causal relationships are dependent on contextual conditions and is furthermore much closer to statistical approaches [85,86]. This article chose the fsQCA method mainly for the following reasons: One is that the traditional statistical analysis method solves the causal relationship between variables, ignoring the mutual influence between the independent variables. The second is that QCA advocates causal asymmetry and can simultaneously propose two paths of high-level configuration and low-level configuration. Third, compared to the two research methods of CsQCA and mvQCA, the fuzzy set has both qualitative and quantitative attributes, and it can distinguish them accurately [87].

4.2. Samples and Data

(1) Sample selection and collection. Based on the research purposes, this article focuses on startups in China. First of all, we conducted a two month follow-up survey at the DZ Automotive Equipment Manufacturing Company in the summer of 2018 (once a week on average) and conducted interviews and exchanges with the company’s general manager and other department heads to understand the company’s knowledge needs, knowledge search methods, market operation models, and a series of problems at this stage, laying a practical foundation for this research. Then, from September 2019 to March 2020, we performed an in-depth examination of the KD technology business incubator to conduct research and interviews with the executives. We came to understand the current situation of incubated enterprises, and understand their knowledge sources and methods, as well as the learning process, which provides important practical support for this study. Finally, our questionnaire was distributed and collected from September 2020 to March 2021. According to the relevant research of “Global Entrepreneurship Monitor- China Report”, it was divided into areas with developed entrepreneurial activities and areas with less developed entrepreneurial activities. Therefore, this study selected enterprises in Shenzhen, Guangzhou, and Beijing as representatives in the entrepreneurship-developed areas, and selected enterprises in Changchun and Shenyang as representatives in the less-developed entrepreneurship areas, which is basically applicable to new ventures in China. Offline, we collected questionnaires through technology parks, incubated enterprises, talent markets, and university seminars, while online, we delivered questionnaires by email and contacted the local alumni association for them to fill in. The reasons for choosing new ventures as the research object were as follows. First, the internal resources of new ventures are more scarce, and they are more dependent on external resources, and the knowledge search activities are more obvious; second, as an emerging market in China, startups occupy a higher proportion; and third, with the intensification of the COVID-19 pandemic, they are facing greater challenges, and so it is more meaningful to study new ventures.

A total of 1036 questionnaires were issued this time, and 545 questionnaires were collected. After excluding those invalid questionnaires with missing data or inadequate answers, a total of 450 valid questionnaires were obtained, accounting for 43.4% of the total number of questionnaires issued. For details, see Table 1.

Table 1. Basic features of the questionnaire.

Feature	Items	Quantity	Percentage
Regional source	Entrepreneurial developed areas	339	75.3%
	Entrepreneurial underdeveloped areas	111	24.7%
Questionnaire Features	Questionnaires issued	1036	52.6%
	Questionnaire recovery	545	
	Questionnaire valid	450	43.4%

(2) The statistical characteristics of the sample. The number of valid samples from Shenzhen, Guangzhou, and Beijing was 339, accounting for 75.3% of the effective sample number, and the number of valid samples from Changchun and Shenyang was 111, accounting for 24.7%. In terms of corporate age, 211 enterprises were less than 5 years old, accounting for 46.9% of the total, and 239 enterprises were 6–8 years old, accounting for 53.1% of the total. In terms of enterprise scale, there were 344 firms with less than 500 employees, accounting for 76.5% of the total, and 106 enterprises with more than 500 employees, accounting for 23.5%. In terms of industry, there were 148 enterprises in the manufacturing industry, accounting for 32.9% of the sample; there were 151 enterprises in the information/computer/software industry, accounting for 33.6% of the total sample; there were 41 enterprises in the retail industry, accounting for 9.1% of the total sample; there were 70 enterprises in the service industry, accounting for 15.6% of the total sample, and there were 40 enterprises in other industries, accounting for 8.9% of the total sample.

Specific sample characteristics are shown in Table 2.

Table 2. Sample characteristics.

Characteristics	Percentage	Characteristics	Percentage
Age		Scale	
1–2 years	18.9%	1–20	3.1%
3–5 years	28.0%	21–50	10.2%
6–8 years	53.1%	51–100	25.6%
Industry		101–200	16.0%
Manufacturing	32.9%	201–500	21.6%
Information industry	33.6%	501–1000	11.3%
Retail industry	9.1%	More than 1000	12.2%
Service industry	15.6%		
Other	8.9%		

4.3. Variables

The condition variables used in this study are external knowledge search, organizational learning, and strategic flexibility, and the result variable is the sustainable innovation. In the questionnaire design process, the following principles were mainly followed: one was to choose a scale that has been cited many times; the second was to adopt a scale with higher reliability and validity; and the third was to choose a widely used scale. First of all, relying on the focal discussion of the original scale of our study by the teachers and doctoral students of our team at the regular academic meeting, we revised the expression content of the items in the scale combined with the topics to be studied, and added and deleted some items to form the scale used in the study, and constructed a research questionnaire. Then, we communicated with entrepreneurs and executives of some new enterprises on the content of the scale and asked them to fill out the questionnaire to see whether each item is clearly expressed with regard to semantics and whether there are any comprehension issues. At the same time, we tested whether each dimension was significant. This research used the 7-point Likert scoring method, where “1” represents completely inconsistent with the item and “7” represents completely consistent with the item. The following is the measurement of each variable in this study.

- (1) Sustainable innovation (SI). This article mainly drew on the research of Story, Boso, and Cadogan [88] and Hansen and Birkinshaw [89], involving a total of 6 items

- such as the innovation ability of the enterprise and the satisfaction of the product or service. Examples include “We have a strong ability to innovate”, “Compared with competitors, our products or services have more advantages”, and so on. The Cronbach’s alpha of this variable was 0.803, and the AVE was 0.54, indicating that it reached acceptable standards in terms of reliability and validity.
- (2) External knowledge search. In terms of a technical knowledge search (TKS) and market knowledge search (MKS), this research referred to the research of Sofka and Grimpe [17] and Ki H and Jina [55]. The formal search (FS) and informal search (IS) are based on the research of Guo B and Guo JJ [18]. Examples include “We are good at seeking technical knowledge through purchasing technology, licensing, etc.”, “We are good at seeking market information such as new sales channels and marketing strategies from enterprises in the same industry through formal cooperation”, “We are good at imitating competitors in the same industry and improving technology”, and “We are good at seeking product or service-related market information from customers through informal communication”. The Cronbach’s alpha of each variable was 0.830, 0.827, 0.816, and 0.803, and the average was 0.40, 0.49, 0.45, and 0.54, indicating that the reliability and validity reached acceptable standards.
 - (3) Organizational learning (OL). This article drew on the research of Morales et al. [90], involving five items including knowledge acquisition ability and knowledge sharing. Examples include “The new knowledge or skills we acquire can bring a competitive advantage to the company” and “We are good at sharing and communicating knowledge to improve our skills.” The Cronbach’s alpha of this variable was 0.772, and the AVE was 0.53, indicating that it reached acceptable standards in terms of reliability and validity.
 - (4) Strategic flexibility (SF). This paper drew on the research of Zhou and Wu [15] and divided strategic flexibility into two dimensions—resource flexibility and coordination flexibility. Examples include “We flexibly allocate production resources to manufacture various products” and “We will effectively redeploy organizational resources to support the firm”. The Cronbach’s alpha of this variable was 0.791 and the AVE was 0.54, indicating that it reached acceptable standards in terms of reliability and validity.

5. Results

5.1. Data Calibration

It is necessary to calibrate the sample data of the result variable and the condition variable before the QCA test. The so-called data calibration involves transforming the existing raw data into fuzzy-set data required for QCA analysis. In addition to constructing total membership points and non-membership points in this study, it is also necessary to build crossover points [83]. Because the mean value represents the degree of aggregation of the data, and the standard deviation represents the degree of dispersion of the data, according to the research method of Kraus et al. [91], the full membership point is set as “the sum of the mean value and a standard deviation”, the non-membership point is set as “the difference between the mean and one standard deviation”, and the crossover point is set to the mean value. The calibration results are shown in Table 3. It can be seen from the results that the consistency level of all the condition variables is less than 0.9, and so there is no necessary condition.

Table 3. Variable calibration results.

Variable	Full Membership	Crossover Point	Non-Membership
SI	6.1296	5.2937	4.4578
TKS	6.0416	5.3873	4.7330
MKS	6.1008	5.4087	4.7166
FS	6.0969	5.4894	4.8819
IS	6.0752	5.3030	4.5308
OL	6.2748	5.4818	4.6888
SF	6.1417	5.3515	4.5614

5.2. Necessity Analysis

Necessity analysis mainly examines the extent to which it constitutes a subset of the condition. If a particular condition variable always appears in the configuration path, it is of necessity, and the measure of the necessity is consistency, the minimum standard of which constitutes a necessary condition, generally considered to be 0.9 [92]. Table 4 shows the conditional necessity test results of conditional variables and outcome variables.

Table 4. Conditional necessity test results.

Variable	High-SI		Low-SI	
	Consistency	Coverage	Consistency	Coverage
TKS	0.7744	0.7847	0.4509	0.4093
~TKS	0.4169	0.4588	0.7627	0.7518
MKS	0.7635	0.7817	0.4546	0.4170
~MKS	0.4307	0.4686	0.7620	0.7426
FS	0.7699	0.7818	0.4586	0.4172
~FS	0.4260	0.4677	0.7601	0.7579
IS	0.7824	0.7849	0.4613	0.4145
~IS	0.4164	0.4631	0.7605	0.7579
OL	0.7898	0.7741	0.4888	0.4291
~OL	0.4175	0.4769	0.7426	0.7599
SF	0.8057	0.7877	0.4729	0.4141
~SF	0.4007	0.4591	0.7577	0.7775

Notes: “~” represents the logical operation “not”. “High-SI” represents the path to enhance sustainable innovation; “Low-SI” represents the path to reduce sustainable innovation.

5.3. Causal Configuration Analysis

Configuration analysis attempts to expose the causal relationship of multiple conditional variables. In constructing the truth table, the adequacy analysis of the configuration is required. According to the research ideas of Ragin [82], this paper sets the case selection frequency to “1”, with the consistency level being greater than 0.8, and the PRI consistency level being greater than 0.75. In the end, we obtain parsimonious, intermediate, and complex solutions. In this paper, the intermediate solution is used as the main reference, and the parsimonious solution is used as an auxiliary reference. As a consistent conclusion of the relationship between the conditional variables and the outcome variables in this paper has not been reached in the academic world; in the analysis process, this article will include all six variables in the “may exist/not exist” option, and analysis by using the software fsQCA3.0 yields the results of the configuration path analysis, as shown in Table 5.

Through the above configuration analysis results, it is found that the solution consistency of high sustainable innovation is 0.8978, which is greater than the acceptable standard of 0.85, and the solution coverage is about 0.64, indicating that a total of 64% of the sample companies are explained. Therefore, these two configuration paths can be used as the driving conditions for the sustainable innovation of the startups. The solution consistency of low sustainable innovation is 0.8768, which is greater than the acceptable standard of 0.85, and the solution coverage is about 0.52, indicating that a total of 52% of the sample enterprises are explained. Therefore, these two paths can be used as a combination of conditions that hinder the sustainable innovation of startups.

Table 5. Configuration path analysis results.

Variable	High-SI		Low-SI	
	Path1	Path2	Path1	Path2
TKS	●	●		⊗
MKS	●		⊗	⊗
FS	●	●	⊗	⊗
IS		●	⊗	
OL	●	●	⊗	⊗
SF	●	●	⊗	⊗
Consistency	0.9167	0.9128	0.8767	0.8814
Coverage	0.5880	0.5786	0.5049	0.5043
Solution consistency		0.8978		0.8768
Solution coverage		0.6434		0.5188

Notes: ● = core causal condition (present), implying that the presence of the condition is crucial to the outcome; ⊗ = core causal condition (absent), suggesting that the absence of the condition is crucial to the outcome; ● = contributing causal condition (present), implying that the presence of the condition is not essential to the outcome; ⊗ = contributing causal condition (absent), suggesting that the absence of the condition is not essential to the outcome; blank spaces indicate that the presence or absence of the condition does not matter with regard to the outcome. “High-SI” represents the path to enhance sustainable innovation; “Low-SI” represents the path to reduce sustainable innovation.

It can be seen from the analysis results that there are two configuration paths for driving high levels of sustainable innovation. In configuration path H1, the technical knowledge search, market knowledge search, organizational learning, and strategic flexibility are the core conditions, and the informal search is the edge condition. Therefore, this paper summarizes this path as a knowledge content-driven path. In configuration path H2, the formal search, informal search, organizational learning, and strategic flexibility are the core conditions, and the market knowledge search is the edge condition. This paper summarizes the path as a search method-driven path.

- (1) Content-driven path (TKS × MKS × OL × SF). This configuration path emphasizes the importance of external knowledge sources. Moreover, the consistency between the condition variables and sustainable innovation is between 0.7 and 0.9, see Table 4. Therefore, we believe these variables are sufficient conditions to affect sustainable innovation. First, new ventures applying this driving path emphasize the importance of technical knowledge and market knowledge in terms of resources. This is consistent with studies by Voss [93] and Sofka and Grimpe [17]. They believed that technical knowledge is a key factor driving product development and innovation [17,46]. The emergence of new technologies will promote the upgrading of products, so that enterprises can gain greater competitive advantages and occupy a higher market share [94]. However, focusing only on technical knowledge and ignoring market knowledge is not advisable. After the enterprise has mastered the relevant market development trend and demanded change information, it can obtain various technical knowledge required for business development in time to protect the existing market position [95]. Thus, new ventures promote sustainable innovation with the combined effect of technical knowledge and market knowledge. Second, new ventures that apply this driving path emphasize the importance of organizational learning and strategic flexibility in terms of capabilities. This is consistent with the results of Liao et al. [96] and Sanchez [97]. They believe that the level of learning ability determines the effect of knowledge utilization, and the application of new knowledge can enhance sustainable innovation among enterprises [96]. In addition, the enterprise has high strategic flexibility, can better integrate and allocate the internal resources, and can cope with the changing external environment [14,97]. To sum up, this configuration path can promote sustainable innovation in new ventures through the resources–capabilities integration.

- (2) Method-driven path (FS × IS × OL × SF). This configuration path emphasizes the importance of searching methods. Moreover, the consistency between the condition variables and sustainable innovation is between 0.7 and 0.9, see Table 4. Therefore, we believe these variables are sufficient conditions to affect sustainable innovation.

First, new ventures applying this driving path emphasize the importance of formal and informal searches in terms of resources. They focus more on knowledge search methods than knowledge sources. This is consistent with the research of Guo B and Guo JJ [18]. They argued that alliances, R&D cooperation, informal exchanges, hiring employees, reverse engineering, professional knowledge training, technology licensing, and patent purchases are all important ways for companies to acquire knowledge resources [18]. Through formal search activities, companies can quickly acquire the knowledge they need and build inter-organizational trust to foster sustainable innovation [98]. An informal search is more conducive to the transfer of tacit knowledge, and the cost is lower [69,99]. In addition, new ventures applying this driving path also emphasize the importance of organizational learning and strategic flexibility in terms of capabilities. In short, through the resources–capabilities integration, this configuration path can also promote sustainable innovation in new ventures.

In addition, two configuration paths have also been derived from this research that lead to reducing sustainable innovation in new ventures, as shown in Table 4. In the configuration path L1, ~FS, ~IS, ~OL, and ~SF are the core conditions, and ~MKS is the edge condition. It can be seen that the lack of knowledge search methods and the lack of organizational learning and strategic flexibility are the reasons for the low sustainable innovation levels of startups. In the configuration path L2, ~TKS, ~MKS, ~OL, and ~SF are the core conditions, and ~FS is the edge condition. It can be seen that insensitivity to the knowledge they need and the lack of organizational learning and strategic flexibility are further reasons for the low sustainable innovation of startups.

5.4. Robustness Test

This study conducted robustness testing by changing the consistency threshold and the number of samples [100,101] to ensure the robustness that drives high sustainable innovation. First, the consistency threshold was increased from 0.8 to 0.85, the sample frequency remained unchanged, and the result did not change compared to before the adjustment.

Second, this study used random sampling to select general samples for re-testing, and the results are shown in Table 6. Comparing Tables 5 and 6, we can see that there are still two paths to drive high levels of sustainable innovation, and the core conditions that constitute this path are roughly the same. Furthermore, their level of consistency and coverage is not very different than before. Therefore, this study can be considered to have good robustness.

Table 6. Robustness test results.

Variable	High-SI	
	Path1	Path2
TKS	●	●
MKS	●	
FKS	●	●
IKS		●
OL	●	
SF	●	●
Consistency	0.9266	0.9370
Coverage	0.6398	0.6171
Solution consistency		0.9268
Solution coverage		0.6657

Notes: ● = core causal condition (present), implying that the presence of the condition is crucial to the outcome; ● = contributing causal condition (present), implying that the presence of the condition is not essential to the outcome; blank spaces indicate that the presence or absence of the condition does not matter with regard to the outcome.

6. Conclusions, Implications, and Limitations

6.1. Conclusions

Based on the open innovation theory and dynamic capability theory, this paper took 450 startups in Shenzhen, Guangzhou, Beijing, Changchun, Shenyang, and other regions of China as the research sample. It took the configuration perspective and used the fsQCA method to explore configuration paths for the sustainable innovation of startups.

First, technical knowledge, market knowledge, a formal search, an informal search, organizational learning, and strategic flexibility are the main factors that affect the sustainable innovation in new ventures. However, they are not sufficient and necessary conditions to affect sustainable innovation—that is, the improvement in sustainable innovation of new ventures is not determined by one variable.

Second, the multiple interactions of resources and capabilities jointly affect the sustainable innovation in new ventures. Only relying on resources or enterprise capabilities cannot drive sustainable innovation. When startups have both resources and enterprise capabilities, sustainable innovation can be achieved.

Third, this study found that there are two pathways to drive the high sustainable innovation levels of startups in China. In the first path, a technical knowledge search, market knowledge search, organizational learning, and strategic flexibility are the core conditions, which is called the knowledge content-driven path. In the second path, a formal search, an informal search, organizational learning, and strategic flexibility are the core conditions, which is called the search method-driven path.

6.2. Theoretical Implications

This research has the following theoretical implications: First, it enriches the open innovation theory and expands the research boundary of the knowledge search. The previous research mainly focused on mature enterprises and reached the research conclusion of over-searching [31,102]. For startups, because they lack resources and rely more heavily on external knowledge, whether they have excessive search behaviors needs to be verified urgently [27]. In addition, in the existing research dimension construction, the duality of the knowledge search is relatively common—for example, search width and search depth [21,31], exploratory search and exploit search [103]. However, such a division approach does not solve the problem of what knowledge startups should search for, who should search for knowledge and how they should search for this knowledge. Therefore, this paper adopts a multi-angle division approach, combining the enterprise knowledge source (knowledge content) and the search method.

Second, it integrates the firm's "resources" and "capacity" frameworks and incorporates them into a research model. Most of the previous literature has addressed the impact of resource acquisition behavior or organizational capabilities on corporate competitiveness and performance or tried to open the black box. However, there is little research on the multivariate interaction of resources and capabilities. Therefore, based on the configuration perspective, this paper incorporates the knowledge search content, knowledge search methods, organizational learning capabilities, and strategic flexibility into a research framework.

Third, this paper presents the configuration paths that drive the sustainable innovation of startups. Most of the previous studies used regression analysis that obtained the marginal effects between variables and failed to draw a path to improve and reduce sustainable innovation. Therefore, this paper explores the integration of knowledge content, search methods, and organizational capabilities, uses the fsQCA method to analyze sample data, and obtains configuration paths that obtain and reduce the sustainable innovation of startups.

6.3. Management Enlightenment

The Fourteenth Five-Year Plan of China states that it is necessary to drive development with innovation and build the capacity for sustainable development in emerging industries. Acquiring the knowledge needed and improving their capabilities have enabled some

Chinese enterprises to develop from technological catch-up to technological leadership. Startups are more dependent on external resources than mature enterprises due to their lack of resources, poor R&D capabilities, and insufficient social relations. Therefore, external knowledge search activities have become essential for startups to acquire new knowledge and maintain competitive advantages. Meanwhile, due to the increased uncertainty in the external environment, startups need to improve their dynamic capabilities through learning and flexible thinking. Therefore, acquiring knowledge through knowledge search activities and improving organizational learning capabilities and strategic flexibility can improve sustainable innovation among startups. The management enlightenment of this paper is mainly reflected in the following aspects:

- (1) New ventures should pay attention to external knowledge sources. It can be seen from this study that technical knowledge and market knowledge are the core to maintaining the sustainable innovation of startups. For them, there are two main ways of acquiring knowledge, which are technological knowledge-dependent and market knowledge-dependent. In the technical knowledge-dependent type, technical knowledge is the core element, and enterprises need to cooperate with suppliers, universities, and research institutions to obtain the technical knowledge. In the market knowledge-dependent type, market knowledge is the core element, and enterprises need to obtain relevant market knowledge from organizations such as customers or competitors in order to change the existing business model or increase market share.
- (2) New ventures should pay equal attention to formal and informal searches. It can be seen from the above research that the use of formal and informal search methods by enterprises is also an important factor in maintaining competitiveness. Startups can quickly acquire a large amount of new knowledge through formal search methods, and the introduction of new production equipment or production lines and the employment of relevant technical personnel have made the inflow of knowledge more obvious. However, using informal search methods is equally important, because only through informal search methods can we obtain tacit knowledge or make tacit knowledge explicit, which is more conducive to sustainable innovation.
- (3) New ventures need to improve their organizational learning capabilities. To cope with the complex external environment, startups need to innovate continuously and develop into a learning organization. Looking at some leading enterprises of China, such as Ali, Tencent, and Huawei, we can see that their rapid development is inseparable from the learning and the formation of sustained competitive advantages. One step is to transform the acquired knowledge into the enterprise's innovation. The second step is to strengthen mutual benefit and trust among organizations, promote knowledge exchange and communication, and increase their knowledge transfer and sharing. The third step is to identify and discover new opportunities through the generation of new knowledge, expand the business scale, and enhance the sustainable innovation of the enterprise.
- (4) New ventures need to improve their strategic flexibility. At present, the survival environment of startups is becoming increasingly turbulent. Measures to survive in this complex and changeable environment have become a primary factor in research. However, it is undoubtedly a good method to allocate resources flexibly and reorganize resources. First of all, startups should pay close attention to changes in the business environment and reduce market risks. Secondly, startups need to improve their management capabilities to increase the integration efficiency of internal and external resources. Finally, business managers should cultivate flexible strategic thinking and form organizational routines. In this way, startups can improve their strategic flexibility and strengthen their current operating conditions to maintain sustainable innovation.

6.4. Limitations and Future Research

Based on the open innovation and dynamic capabilities theory, this paper constructed an integrated framework of resource acquisition behavior and capabilities from the perspective of configuration, explored the configuration path that drives the sustainable innovation of startups, and obtained some theoretical and practical implications. However, this research still has the following limitations. First, there are limitations in the research area and sample selection. In the future, sample sources and sample sizes can be expanded, and more regional data can be collected as samples to improve the quality and applicability of the research. Second, this paper did not subdivide enterprises according to the industry to which they belong. Since the ability and knowledge search activities of enterprises are affected by industry factors, the manufacturing, information, and service industries can be subdivided to study the drivers of sustainable innovation in a certain industry. Third, there are other integration frameworks in terms of resource acquisition methods and corporate capabilities. In future research, other different variables can be selected for study.

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