

Article

R&D Transfer and Financing in Emerging Economies: An Exploratory Approach Toward Sustainable Tech-Entrepreneurship

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Abstract

This study examines the direct effects of R&D transfer and the sufficiency of financing for entrepreneurs on Technological Total Entrepreneurial Activity (TechTEA), as well as the mediating role of financing. The analysis employs a variance-based structural equation modeling approach (PLS-SEM) to explore causal relationships among the variables. Data are drawn from the Global Entrepreneurship Monitor (GEM), specifically the National Expert Survey (NES) and the Adult Population Survey (APS), covering 26 emerging economies. The findings reveal that R&D transfer has a significant positive effect on the sufficiency of financing available to entrepreneurs. However, R&D transfer shows a significant negative direct effect on TechTEA. In contrast, the sufficiency of financing has a positive impact on TechTEA, acting as an inconsistent mediator that neutralizes the negative direct friction of R&D and unlocks its positive indirect potential. The study demonstrates that Resource-Based View (RBV) principles operate in a fundamentally distinct manner within emerging economies. Raw technical knowledge (R&D transfer) and capital injections (sufficiency of financing) are not self-sufficient drivers of high-tech ventures in developing contexts. From a sustainability perspective, this dynamic suggests that institutional and ecosystem frictions can impede the Triple Bottom Line, as technological potential struggles to achieve the economic viability required for long-term societal impact. Consequently, achieving genuine ecosystem sustainability requires policymakers to shift away from isolated, supply-side resource injections. Future strategies must pivot toward comprehensive institutional governance, friction-reduction mechanisms, and cross-sector regulatory coordination to enable technological ventures to successfully scale and survive over time.



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1. Introduction

According to the World Commission on Environment and Development [1], sustainability fundamentally requires the efficient use of resources to meet present and future needs. When this core principle is operationalized in business through Elkington's [2] Triple Bottom Line, economic performance emerges as a foundational and non-negotiable pillar of sustainability, given that environmental protection or social equity can rarely be structurally maintained by a bankrupt firm. Therefore, while Technological Entrepreneurial

Activity (TechTEA) empirically captures the emergence of medium- and high-tech firms, it is conceptually understood within this framework as a critical prerequisite and baseline enabler for addressing broader societal issues and building resilient, green industries [3,4]. Rather than disconnecting TechTEA from the multidimensional nature of sustainability, this exploratory approach acknowledges that for medium and high tech ventures to successfully deliver substantive environmental and social value over time, they must first survive by successfully navigating the complex, primary interplay between knowledge creation and financial sufficiency.

In alignment with this economic prerequisite, technological entrepreneurship has been documented as a powerful mechanism to create wealth, drive economic development, and enhance employment and productivity across nations [5,6]. While entrepreneurship encompasses a full spectrum of productive activities, its ability to foster long-term resilience is increasingly associated with systemic innovation and technology-driven ventures [5]. In this context, technological entrepreneurship has gained significant global attention due to the unique capacity of high-tech firms to convert disruptive scientific knowledge into tangible market value [7,8]. However, modern discourse suggests that the ultimate goal of these ecosystemic efforts must transcend short-term market entry, aiming instead toward the execution of a sustainable technological venture that ensures the long-term viability of the firm and its contributions to society.

Technological Entrepreneurial Activity has been studied at individual and organizational levels. At the individual level, studies on technological entrepreneurs investigate how founders learn from their customers and convert those learnings into sources of information or into a co-creation process [9]. Technological entrepreneurs may be influenced by non-economic goals when developing a new business. Usually, technological entrepreneurs come from the academic field, and this academic identity, or the proself, is a non-economic motivator for developing the technology needed for the nascent firm, but it could also lead to lower growth aspirations [10,11]. At the organizational level, the absorptive and adaptive capacities of technology firms help them exploit business opportunities, thereby increasing their business resilience in times of crisis [12]. Other factors contributing to the success of technology firms included business model innovation, the founders' prior professional experience, and inter-organizational learning [3].

Although individual and organizational perspectives exist in the technological entrepreneurship literature, studies at the entrepreneurial ecosystem level are missing, creating a gap regarding the determinants of entrepreneurial technological activities at the ecosystem level.

The entrepreneurial ecosystem (EE) components are exceptionally broad, and analyzing all systemic aspects simultaneously presents a significant methodological challenge due to its inherent complexity [13]. Consequently, this study unifies the entire model under the framework of the Extended Resource-Based View (RBV) applied to entrepreneurial ecosystems [14,15]. Grounded in this unified framework, we replace generic ecosystem concepts with a more specific formulation: we focus strictly on the interaction between knowledge-based resources (operationalized as the level of R&D transfer) and financial resources (operationalized as the sufficiency of financing for entrepreneurs) [16]. Following this Extended RBV logic, environmental dimensions within an ecosystem do not operate in isolation; rather, they function as bundles of complementary assets that require mutual mobilization to unlock commercial value [17].

Furthermore, technological activities are inherently capital-, talent-, and knowledge-intensive [8,12]. As a result, R&D efforts by individuals or organizations can be heavily constrained by the institutional voids embedding their entrepreneurial ecosystems [4,18], ultimately limiting technology's potential to deliver broader social benefits.

Finally, unlike advanced economies, Technological EEs in emerging markets are typically created artificially through public institutional support and international connectivity, often lacking natural, organic resource providers [4]. Isolating this specific dimension of the Technological EE is therefore crucial, as its dynamics operate under fundamentally different rules in emerging contexts.

This paper examines ways to foster technological entrepreneurship through the variables of R&D transfer and financing sufficiency. Analyzing these variables is critical, as they enhance a country's economic growth and reduce its vulnerability to external shocks. Fostering technological entrepreneurship through R&D and targeted financing serves as a pivotal leverage point that allows emerging markets to escape economic crises more rapidly [18,19]. Furthermore, studying the interplay among financing, R&D, and technological entrepreneurial activity helps identify mechanisms to prevent instability in highly vulnerable, tech-dependent strategic sectors [20].

Although the study of technological entrepreneurial activities has traditionally been approached from an institutional standpoint—such as through national innovation systems or financial environments—these frameworks often analyze the isolated effects of innovation [18,19]. Rather than evaluating these components in isolation, we adopt an entrepreneurial ecosystem perspective based on the interaction between two distinct dimensions: the R&D level of transfer and entrepreneurial financing. We present these two variables as key enablers of technological entrepreneurship. Ultimately, studying innovation and technology from an entrepreneurial ecosystem perspective is necessary to generate a meaningful societal impact through technology. Therefore, this study analyzes the specific mechanisms through which R&D transfer and sufficiency of financing for entrepreneurs enable technological entrepreneurial activities in emerging economies.

This paper also contributes to the literature on entrepreneurial ecosystems by focusing on emerging markets, a context that is particularly relevant due to its distinctive characteristics, including institutional voids—especially capital market imperfections—as well as knowledge deserts and limited absorptive capacity for knowledge from foreign technological firms operating in these economies [4,21].

This study examines the direct effects of knowledge-based resources (the level of R&D transfer) and financial resources (the sufficiency of financing for entrepreneurs) on Technological Total Entrepreneurial Activity (TechTEA), as well as the mediating role of financing within emerging economies. Utilizing data from the Global Entrepreneurship Monitor (GEM)—specifically the National Expert Survey (NES) and the Adult Population Survey (APS)—we analyze a sample of 26 emerging countries, leveraging individual expert evaluations to capture the qualitative nuances of these ecosystems. The structural relationships among variables are evaluated using variance-based structural equation modeling (PLS-SEM).

The findings reveal that R&D transfer has a significant positive effect on the sufficiency of financing available to entrepreneurs. However, R&D transfer shows a significant negative direct effect on TechTEA, suggesting that isolated technology transfer introduces systemic friction. In contrast, the sufficiency of financing has a positive impact on TechTEA, acting as an inconsistent mediator that neutralizes the negative direct friction of R&D and unlocks its positive indirect potential. Crucially, our exploratory model's low overall explanatory power challenges the status quo in the technological entrepreneurship literature, delivering a critical diagnostic insight: in emerging economies, the traditional assumption that technical knowledge and capital injections are the primary, self-sufficient drivers of high-tech ventures does not hold true, as these pillars explain a mere 1.5% of the phenomenon. While financial resources act as a localized vehicle to offset the negative friction of isolated technology transfer, widespread macro-level TechTEA depends

on a much broader, multi-layered configuration of institutional governance and market alignment. Consequently, this empirical result suggests that explaining technological entrepreneurship in developing contexts requires looking far beyond the traditional resource variables emphasized in Western-centric models [22]. Those traditional models—rooted in classical Resource-Based View (RBV) and linear innovation theories—typically focus strictly on isolating supply-side factors such as national R&D activities and capital availability [23–25]. By indicating that these classical inputs leave 98.5% of the variance unexplained, our exploratory study provides an initial baseline suggesting that Western-centric frameworks may be structurally incomplete for emerging markets. This supports Bruton et al. (2010) [26], who argue that entrepreneurship in developing contexts requires shifting from purely resource-centric views toward institutional lenses due to environmental constraints and institutional voids.

In this sense, macro-level analyses like ours can serve as a foundation for future research aimed at uncovering the microfoundations of entrepreneurial ecosystems' resource allocation in the technology sector within emerging markets, particularly by guiding attention toward the interactions and processes that drive variation in entrepreneurial activity and outcomes across contexts [22,27].

The paper is organized as follows. First, it presents the literature review. Next, it describes the PLS-SEM methodology employed in the study. Section 5 begins with an assessment of the construct's reliability and validity, followed by the presentation of direct and indirect effects. Section 6 follows, and the paper concludes with the study's main conclusions and implications.

2. Literature Review

2.1. *Technology Entrepreneurship and Entrepreneurial Ecosystems*

Technology entrepreneurship has been defined as “an investment in a project that assembles and deploys specialized individuals and heterogeneous assets that are intricately related to advances in scientific and technological knowledge for the purpose of creating and capturing value for a firm” ([8], p. 11). This definition underscores the centrality of projects that rely on highly specialized human capital and integrate diverse resources to generate and appropriate value. Compared to entrepreneurship more broadly, technology entrepreneurship entails a higher degree of specialization in both capabilities and assets, as well as the need for a shared, forward-looking vision grounded in scientific and technological change. This reliance on advances in science and technology is what fundamentally distinguishes it from other forms of entrepreneurial activity. As a result, technology entrepreneurship plays a particularly important role in society, given its potential to generate more disruptive and transformative forms of value creation.

The societal relevance of technology entrepreneurship is evident in its contribution to addressing major global challenges, including public health, energy transition, and urban mobility [28]. Technological innovations can improve population health through enhanced nutrition knowledge, increased physical activity, continuity of care enabled by digital tools and mobile applications, and the use of data monitoring systems and electronic health records [29,30]. Similarly, technology facilitates the development of adaptive urban environments that respond to evolving social dynamics, improving public service delivery and mobility [31]. Other innovations, such as autonomous vehicles, are expected to reduce traffic accidents and environmental pollution [32]. These examples illustrate how technology-driven ventures can produce significant societal benefits. However, as Elkington (1997) [2] proposed through the Triple Bottom Line framework, for these contributions to be truly sustainable, they must balance social and environmental progress with financial viability. Therefore, the sustainability of these ventures depends on their ability to integrate

societal value creation with a robust economic foundation, ensuring their long-term impact on the entrepreneurial ecosystem.

However, the emergence and growth of such ventures cannot be understood in isolation. Technology entrepreneurship is inherently embedded in entrepreneurial ecosystems (EEs), which provide the structural conditions and interactions necessary for developing high-impact innovations. These ecosystems comprise a diverse set of interdependent actors, including startups, established firms, venture capitalists, research institutions, innovation hubs, incubators, accelerators, and government agencies, all of which contribute to knowledge production and the commercialization of technology [28,33–35].

To fully understand technological entrepreneurial ecosystems, it is essential to adopt a processual perspective that captures their dynamic and evolving nature [27]. In this regard, Brown and Mason (2017) [36] identify four core components of entrepreneurial ecosystems: (1) entrepreneurial actors, including nascent, novice, serial, and portfolio entrepreneurs; (2) resource providers, which supply critical assets such as financing, infrastructure, and public support; (3) connectors, which link entrepreneurs with resources through networks, support programs, and talent pipelines; and (4) entrepreneurial culture.

Crucially, the literature suggests that simply injecting resources into an EE does not guarantee success [16]; therefore, shifting the academic conversation from an inventory of present actors to the underlying dynamics of resource interdependence becomes paramount. By extending this view through the lens of the Resource-Based View (RBV), it becomes evident that environmental pillars function as bundles of complementary assets [14,15]. By exploring the mediating effect of financing sufficiency between R&D transfer and technological entrepreneurship (TechTEA), this paper illustrates not only how resources independently affect outcomes, but fundamentally how they affect each other. Following this Extended RBV logic, a latent knowledge asset like R&D transfer may often rely on a strategic financial resource to help unlock and mobilize its commercial potential [32].

2.2. Technological Entrepreneurial Activity in Emerging Markets

Emerging markets exhibit distinct performance in Technological Entrepreneurial Activity. Usually, technology-based entrepreneurial ecosystems are artificially created in emerging economies due to a knowledge desert and insufficient knowledge to transform them into entrepreneurial firms. Giblin et al. (2025) [4] found that the medical technology sector in Costa Rica emerged due to public institutional support and international connectivity. However, this is not inherently bad; the country lacks the capacity to absorb knowledge from abroad and translate it into entrepreneurial firms.

Emerging markets exhibit financial constraints. Venture capitalists and angel investors typically base their investment decisions on the host country's market size, as well as on whether society possesses the necessary critical capacity and technical skills to adopt and consume technological products at a massive scale. Generally, populations in emerging economies lack these specialized capabilities [18,20,37]. Consequently, technology ventures in these regions must rely heavily on internal financing due to deep capital market imperfections that restrict access to external funding channels [21].

3. Hypothesis

The conceptual framework of this study is grounded in the definitions provided by the Global Entrepreneurship Monitor (GEM). Within this framework, the R&D Level of Transfer refers to the extent to which national research and development activities generate new commercial opportunities and are accessible to small and medium-sized enterprises (SMEs). Sufficiency of Financing for Entrepreneurship captures the availability of financial resources—both equity and debt—for SMEs, including grants and subsidies.

Finally, Technological Entrepreneurial Activity (TechTEA) is defined as the percentage of the population aged 18–64 who are either nascent entrepreneurs or owner-managers of new ventures (less than 3 years old), with this study focusing specifically on those engaged in medium- and high-technology sectors.

To explore the complex dynamics between these systemic pillars, this study models their interactions through an Extended Resource-Based View (RBV) lens within the entrepreneurial ecosystem [15,38]. Rather than treating these environmental components as isolated factors, we propose a structural pathway where a latent knowledge asset (R&D Level of Transfer) may often rely on a complementary mobilizing mechanism (Sufficiency of Financing) to translate technological potential into active, high-impact commercial outcomes (TechTEA). Consequently, the following sections derive and present four distinct hypotheses: first, the link between technology transfer and its capacity to stimulate environmental financial flows (H1); second, the direct connection between financial sufficiency and medium–high tech firm creation (H2); third, the foundational baseline influence of R&D transfer on technological entrepreneurship (H3); and fourth, the central mediation mechanism (H4).

3.1. R&D Level of Transfer and Sufficiency Financing of Entrepreneurship

The availability of an entrepreneurial ecosystem for producing technology-based innovative products is related to the investment decisions of Venture Capital Funds and angel investors [37]. Public institutions usually fund R&D projects; these seed funds reduce the cost of external capital and help mature the technology until market-based financing can see a business opportunity to invest in [23]. The programs from the government and university to foster R&D transfer can specifically increase the quantity and quality of patents and technological developments, making technological projects more attractive to investors and increasing the availability of funds to support the early years of technological startups. As a key example, we have the Defense Advanced Research Projects Agency (DARPA) in the United States. DARPA has funded foundational technologies such as the internet, personal computers, and materials science, which were highly uncertain and disruptive at the time, and the Bundesagentur für Sprunginnovationen (SPRIN-D) in Germany, which is designed to support breakthrough innovations [6,24].

Well-structured technology transfer mechanisms can enhance entrepreneurial financing by reducing early-stage risks and demonstrating commercial potential. Technology Transfer Offices (TTOs) play an important role in managing proof-of-concept (POC) funding, which serves as an early-stage financial bridge between invention and market readiness [38].

Based on the above arguments, the following hypothesis is proposed:

Hypothesis 1 (H1). *The R&D level of Transfer has a positive and significant impact on Sufficiency Financing of Entrepreneurship.*

3.2. Sufficiency Financing for Entrepreneurs and Technological Entrepreneurial Activity

Sufficient financing plays a critical role in the growth of technological startups by addressing monetary needs. The availability of diverse funding sources, including equity and debt providers, allows startups to access resources tailored to their specific developmental phase and operational requirements, thereby supporting their growth trajectory [39].

In the context of the startup ecosystem, private investments such as seed, angel, corporate venture capital, and private equity enhance startup innovation performance and contribute to the rapid expansion of technological startups [40,41]. For generative artificial intelligence (GAI) startups, angel and seed funding are essential for early growth [42].

The growth trajectory of technological startups is influenced by the level and timing of financing they receive, as well as the economic context at their inception. Public venture

capital initiatives, such as government-subsidized participative loans, have been shown to positively affect short-term growth indicators for startups, such as sales, labor productivity, and intangible asset intensity [43].

Based on the above arguments, the following hypothesis is proposed:

Hypothesis 2 (H2). *Sufficiency of Financing for Entrepreneurs has a significant and positive influence on Technological Total Entrepreneurial Activity.*

3.3. R&D Level of Transference and Technological Entrepreneurial Activity

On one hand, the traditional literature posits that country-level R&D investments are positively associated with individual entrepreneurial performance. From this perspective, greater national R&D activity expands the collective knowledge stock, creating highly specialized opportunities for entrepreneurs to deploy advanced technologies and capture commercial value [25]. Within this dynamic, knowledge transfer activities—particularly those operationalized through university Technology Transfer Offices (TTOs)—play a fundamental role. These entities manage the bridge between scientific research and the commercial marketplace, structurally facilitating the formal creation and subsequent growth of technological startups [44]. Supporting this view, Alvarado-Vargas et al. (2017) [45] observe that development-focused R&D activities, which deliberately utilize scientific knowledge to generate new products, are strongly associated with increased university spin-off creation, suggesting that systemic investment in research translation yields direct entrepreneurial returns.

On the other hand, research recognizes that the relationship between knowledge transfer and firm creation is not always linear, frequently exhibiting paradoxical outcomes within the institutional constraints of emerging markets. In these specific contexts, the mere generation or institutional transfer of technology often proves insufficient to stimulate active entrepreneurial outcomes. This disconnect can be conceptually understood through the lens of user path convergence [46]. When a structural misalignment exists between scientific outputs and market readiness—meaning there is an absence of path convergence—technological innovations fail to achieve commercial adoption despite intensive promotional efforts by technology entrepreneurs.

Based on the above arguments, the following hypothesis is proposed:

Hypothesis 3 (H3). *R&D Level of Transference significantly influences Technological Total Entrepreneurial Activity.*

3.4. The Mediating Role of Financing Sufficiency

The entrepreneurial ecosystems (EE) framework indicates that structural pillars do not operate in isolation; their efficacy depends on systemic interdependence [38], meaning that simply injecting resources does not guarantee tech-firm emergence [16]. Through the lens of the Resource-Based View (RBV), environmental dimensions function as bundles of complementary assets requiring mutual mobilization [14,17]. Consequently, a latent knowledge asset like R&D Level of Transfer represents market potential that often remains passive due to ecosystem friction, relying on other resources to act as an absorptive bridge to unlock its commercial value.

Sufficiency of Financing for Entrepreneurship functions as this systemic catalyst. Within high-tech ecosystems, private mechanisms like seed, angel, corporate venture capital, and private equity significantly enhance innovation and drive rapid market expansion [40,41]. This financial baseline is critical in cutting-edge industries; for instance, in emerging fields like generative artificial intelligence (GAI) startups, early-stage angel and seed funding acts as an essential lifeline for initial growth [42]. Financial infrastruc-

ture provides the liquidity and capital bundling necessary for entrepreneurs to tolerate the high-risk, long-gestation cycles inherent in advanced technology sectors [43]. When financial sufficiency is present, it actively channels and materializes raw innovative inputs into commercial realities. Therefore, this paper proposes that the impact of technology transfer on technological entrepreneurship is mediated through complementary financial resources:

Hypothesis 4 (H4). *The Sufficiency of Financing for Entrepreneurship mediates the relationship between the R&D Level of Transfer and Technological Total Entrepreneurial Activity (TechTEA).*

4. Method

PLS-SEM is an exploratory causal modeling technique that estimates path coefficients, enabling the examination of relationships among latent variables through the testing of theoretically grounded hypotheses [47]. Unlike simple correlation analysis, which does not imply causality, PLS-SEM allows for the estimation of direct causal relationships between constructs. For this reason, it is particularly well suited to the objective of this study, which is to explore the causal relationships among key variables—namely, Sufficiency of Financing for Entrepreneurship, R&D Level of Transfer, and Technological Total Entrepreneurial Activity (see Figure 1).

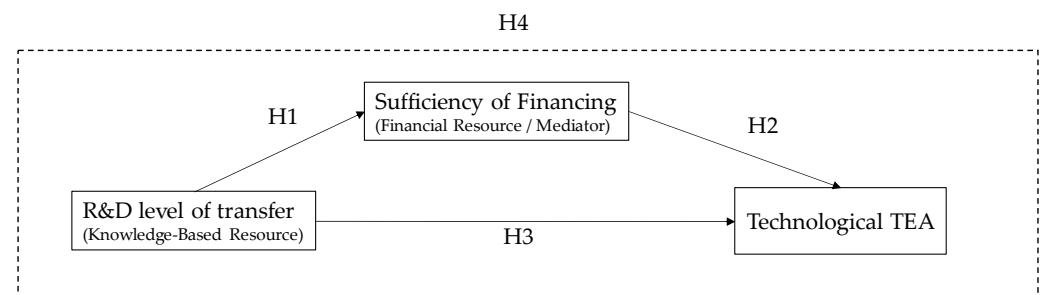


Figure 1. Structural PLS-SEM model operationalized under the Extended Resource-Based View (RBV).

Using PLS-SEM in this context offers methodological advantages over alternative approaches, such as panel data analysis or regression-based mediation. In emerging economies, comprehensive information regarding entrepreneurial ecosystems is frequently scarce, and compiling multi-year or objective quantitative data is highly challenging due to severe data fragmentation and shifting institutional definitions across borders [48]. These systemic constraints heavily justify the cross-sectional, exploratory nature of this study. Furthermore, traditional regression or panel data models typically sacrifice the granular richness of individual indicators by relying on aggregated construct averages. In contrast, PLS-SEM preserves the variance of each specific item, preventing the loss of critical diagnostic information.

Methodologically, this study relies on individual expert-level responses from the Global Entrepreneurship Monitor (GEM) database. Rather than treating experts as aggregate country averages, keeping them as individual observations allows them to act as comprehensive sensors capable of perceiving and evaluating the subtle, qualitative nuances of financial sufficiency and R&D transfer within their respective environments [49]. By linking these individual expert perceptions directly to the country-level technological entrepreneurship indicator (TechTEA), the model effectively captures how the perceived institutional reality of an ecosystem functions as a catalyst for actual entrepreneurial outcomes.

The study is based on data from the Global Entrepreneurship Monitor (GEM), specifically the National Experts Survey (NES) and the Adult Population Survey (APS), collected

in 2021. The NES questionnaire is used to collect the views of experts on a wide range of items, each of which was designed to capture a different dimension of the entrepreneurial framework conditions, and the GEM APS is a unique instrument used to measure the level and nature of entrepreneurial activity around the world [50]. The NES and APS databases were grouped into one region based on the Below-median Human Development Index (BHDI) classification. The concept of below-median is embedded within a broader analytical framework that considers different population percentiles. Examining multiple quantiles (below, above, and intermediate ranges) provides a richer, more nuanced understanding of human development than relying solely on averages. In this context, the BHDI captures the average achievements of individuals below the median within a country across key dimensions of human development: the Below-median Life Expectancy Index (LEIB), the Below-median Income Index (IIB), the Below-median Mean Years of Schooling Index (MYSIB), and the Below-median Expected Years of Schooling Index (EYSIB) [51].

According to the BHDI from the total of countries available on the Global Entrepreneurship Monitor (NES and APS), the emerging markets are: Russia, Egypt, South Africa, Greece, Romania, Brazil, Chile, Colombia, Turkey, India, Iran, Morocco, Sudan, Cyprus, Belarus, Croatia, Slovak Republic, Guatemala, Panama, Uruguay, Kazakhstan, Saudi Arabia, Oman, United Arab Emirates, Qatar and Dominica. The sample sizes were balanced with 992 observations from 26 emerging markets and an average of 37 respondents per country. The 26 countries were chosen because they are the most representative of emerging markets according to the Below-median Human Development Index (BHDI) [51], and their information was available.

The data analysis was conducted using a variance-based structural equation modeling approach, specifically partial least squares (PLS-SEM), implemented in SmartPLS version 3.0. This technique was selected because it is a second-generation statistical method widely used in empirical social science research, particularly suited for modeling latent (unobservable) variables measured indirectly through indicator variables [47].

The latent constructs in this study were derived from the National Expert Survey (NES), which captures informed assessments of national entrepreneurial framework conditions. On average, the NES includes responses from 37 experts per country. These national and regional experts are selected based on their reputation and experience, through a convenience sampling approach. The use of latent variables is also justified by the difficulty of harmonizing comparable indicators across the 26 countries included in the analysis.

As illustrated in Figure 1, the structural design of our empirical model is fully unified under the framework of the Extended Resource-Based View (RBV) applied to entrepreneurial ecosystems. Rather than analyzing independent, isolated pillars, this structural model captures the fundamental principles of resource interdependence and complementarity within emerging economies. Specifically, the framework unifies the model by positioning the level of R&D transfer as a core knowledge-based resource whose capacity to drive Technological Total Entrepreneurial Activity (TechTEA) is conditionally mediated by a critical, complementary financial resource (Sufficiency of Financing). By structuring these paths simultaneously, the model operationalizes how configuration and resource interaction—rather than a static inventory of assets—determine high-tech venture outcomes in resource-constrained environments.

Measurement of the Study Variables

Given the complexity of institutional voids and the scarcity of synchronized data in emerging economies, this exploratory study adopts a PLS-SEM approach to uncover the mediating mechanisms that govern technological entrepreneurship.

The Sufficiency of Financing for Entrepreneurship and the Level of Transfer in R&D in this study were operationalized using standardized measures derived from the Global Entrepreneurship Monitor (GEM) datasets. Specifically, the constructs of R&D Level of Transfer and Sufficiency of Financing for Entrepreneurship were measured using an 11-point Likert-type scale ranging from 0 to 10, with higher values indicating more favorable conditions.

Technological Total Early Stage Entrepreneurial Activity (TechTEA) was measured as the percentage of the population aged 18–64 in a country who are either nascent entrepreneurs or owner-managers of new businesses (less than three years old). From this group, we specifically consider only those engaged in medium- and high-technology ventures.

Following the contemporary literature that utilizes Global Entrepreneurship Monitor (GEM) data within PLS-SEM frameworks [52], the constructs for R&D Level of Transfer and Sufficiency of Financing for Entrepreneurs were operationalized as reflective. While both constructs conceptually encompass multiple dimensions, the GEM National Expert Survey evaluates these conditions through unified, perceptual Likert scales designed to capture the overarching systemic adequacy of the ecosystem rather than tracking additive, independent causes. This reflective specification aligns with standardized practices for analyzing perceptual macroeconomic indicators. Empirically, this operational choice is fully supported by robust indicator outer loadings, excellent Composite Reliability, and an Average Variance Extracted comfortably exceeding the 0.50 benchmark, confirming that the items reflect a high degree of shared variance.

The Global Entrepreneurship Monitor created the measurement of each variable; the items of the variables are the following:

1. Sufficiency of Financing for Entrepreneurship: This condition was measured with eight items on an eleven-point Likert scale comprising the following statements: (a) In my country there is sufficient: equity funding (understood as entrepreneurs' own financial resources) available for new and growing firms; (b) In my country there is sufficient: debt funding (understood as bank loans and similar) available for new and growing firms; (c) In my country there is sufficient: government subsidies available for new and growing firms; (d) In my country there is sufficient: informal investor funding (family, friends and colleagues who are private individuals other than founders) for new and growing firms; (e) In my country there is sufficient: professional business angel funding (individuals who provide capital in exchange for convertible debt or ownership equity) for new and growing firms; (f) In my country there is sufficient: venture capital funding (pooled investment funds for private equity stakes) for new and growing firms; (g) In my country there is sufficient: IPO (initial public offering) funding available for new and growing firms; (h) In my country there is sufficient: micro funding (for example crowdfunding from a large number of individuals contributing a relatively small amount, typically via the internet) for new and growing firms.
2. R&D Level of Transfer: This condition was measured with six items on an eleven-point Likert scale comprising the following statements: (a) In my country, new technology, science, and other knowledge are efficiently transferred from universities and public research centers to new and growing firms; (b) In my country, new and growing firms have just as much access to new research and technology as large, established firms; (c) In my country, new and growing firms can afford the latest technology; (d) In my country, there are adequate government subsidies for new and growing firms to acquire new technology; (e) In my country, the science and technology base efficiently supports the creation of world-class new technology-based ventures in at least one

area; (f) In my country, there is good support available for engineers and scientists to have their ideas commercialized through new and growing firms.

5. Results

5.1. Descriptive Analysis

The exploratory descriptive analysis of emerging markets for 2021 points toward a nascent and seemingly constrained technological ecosystem. While the Technological TEA averages 3.72%, it sits toward the lower end of the observed spectrum, potentially suggesting that tech-based entrepreneurship is still in its early stages of development. Certain systemic barriers appear to align with this limited growth: the Sufficiency of Financing (4.08 out of 10 points) and R&D transfer (3.43 out of 10 points) both score below the midpoint of the scale. These initial observations may indicate that a lack of capital for entrepreneurs and a disconnect between academia and industry represent prevalent challenges within the sample. Consequently, these environmental constraints could be tentatively linked to the difficulties these economies face in advancing their TechTEA potential (see Table 1). Given the exploratory nature of this study, these descriptive trends are interpreted with caution as preliminary indicators of ecosystem friction.

Table 1. Descriptive variables in emerging markets.

Variable	Average	Standard Deviation	Maximum	Minimum
TechTEA	3.72	2.39	9.87%	0.37%
Sufficiency of Financing for Entrepreneurs	4.08	0.96	6.19	2.31
R&D Level of Transfer	3.43	0.98	5.79	2.01

5.2. Measurement Model Assessment

5.2.1. Reliability, Content and Convergent Validity

As shown in Table 2, the item loadings for most indicators exceed the recommended threshold of 0.70. Four indicators exhibited a loading between 0.639 and 0.693; however, following the guidelines of Hair et al. (2017) [47], indicators with loadings between 0.40 and 0.70 should be retained if their removal does not noticeably increase the Composite Reliability (CR) or the Average Variance Extracted (AVE) of the construct. Since both the CR and AVE for this construct comfortably exceeded their respective thresholds of 0.70 and 0.50, the indicator was retained to preserve content validity within this exploratory framework.

The evaluation of the measurement model, as shown in Table 3, demonstrates satisfactory levels of internal consistency, reliability, and convergent validity across the latent constructs. Specifically, Cronbach's alpha values exceed the conventional threshold of 0.70 [53], with 0.860 for Sufficiency of Financing for Entrepreneurs and 0.917 for R&D transfer, indicating strong internal consistency. Composite Reliability indices (rho_a and rho_c) further confirm robustness, with all values exceeding 0.85, thereby ensuring the stability of the latent constructs under PLS-SEM estimation [54].

Convergent validity (see Table 3) is supported by Average Variance Extracted (AVE) values of 0.506 (Financing) and 0.752 (R&D transfer), both exceeding the minimum threshold of 0.50 [47]. This indicates that the constructs explain more than half of the variance of their indicators, satisfying the criteria for construct validity in reflective measurement models. Construct validity is understood as the degree of correspondence between a measure at the conceptual level and the empirical measure used in the study [55].

Table 2. Outer loadings.

Items	Sufficiency of Financing for Entrepreneurs	R&D Level of Transfer	TechTEA
NES21_A01	0.724		
NES21_A02	0.693		
NES21_A03	0.718		
NES21_A04	0.660		
NES21_A05	0.752		
NES21_A06	0.802		
NES21_A07	0.691		
NES21_A08	0.639		
NES21_I01		0.855	
NES21_I02		0.917	
NES21_I03		0.895	
NES21_I04		0.881	
NES21_I05		0.784	
TechTEA			1.000

Table 3. Reliability and convergent validity measures.

Variable	Cronbach's Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted (AVE)
Sufficiency of Financing for Entrepreneurs	0.860	0.866	0.891	0.506
R&D Level of Transfer	0.917	0.926	0.938	0.752

5.2.2. Discriminant Validity Measures

Discriminant validity helps establish that the construct under analysis is unique and captures phenomena not represented by other constructs in the model [56]. To ensure a rigorous assessment, discriminant validity was evaluated using two distinct methods: the traditional Fornell–Larcker criterion and the Heterotrait–Monotrait ratio (HTMT) approach.

First, according to the Fornell–Larcker criterion, a latent variable should account for more variance in its own associated indicators than it shares with other constructs [57]. This condition is satisfied when the square root of the Average Variance Extracted (AVE) for each individual construct is greater than its highest correlation with any other construct. In Table 4, we can observe that the square roots of the AVE (located on the diagonal) for Sufficiency of Financing for Entrepreneurs (0.712) and R&D Level of Transfer (0.867) comfortably exceed their respective inter-construct correlations (off-diagonal values), thus confirming discriminant validity through this traditional metric.

Table 4. Fornell–Larcker discriminant validity.

Variable	Sufficiency of Financing for Entrepreneurs	R&D Level of Transfer	TECHTEA
Sufficiency of Financing for Entrepreneurs	0.712		
R&D Level of Transfer	0.361	0.867	
TECHTEA	0.092	-0.028	1.000

Second, the Heterotrait–Monotrait ratio (HTMT) was examined as a modern, more stringent standard. HTMT values should remain strictly below the conservative threshold of 0.85, or the standard benchmark of 0.90, to establish clear distinction between constructs [58]. As detailed in the lower section of Table 5, the highest observed HTMT ratio is between R&D Level of Transfer and Sufficiency of Financing for Entrepreneurs (0.397), while the remaining ratios fall well below 0.10. These values confirm that all constructs possess robust discriminant validity.

Table 5. Heterotrait–Monotrait ratio (HTMT).

Variable	Sufficiency of Financing for Entrepreneurs	R&D Level of Transfer	TECHTEA
Sufficiency of Financing for Entrepreneurs			
R&D Level of Transfer	0.397		
TECHTEA	0.096	0.045	

5.3. Structural Model Evaluation

5.3.1. Model Fit

To evaluate the overall quality of the structural model, the model fit criteria were examined. The Standardized Root Mean Square Residual (SRMR) yielded a value of 0.056 for both the saturated and estimated models, well below the conservative threshold of 0.08 recommended by Henseler et al. (2014) [58], indicating a good model fit.

5.3.2. Direct Effects and Hypothesis Testing

The structural model reveals statistically significant relationships among the constructs, although their magnitudes vary considerably (see Table 6). To evaluate the significance of these paths, a non-parametric bootstrapping procedure with 5000 subsamples was executed to generate 95% bias-corrected confidence intervals (CIs). The path from R&D transfer to Sufficiency of Financing for Entrepreneurs is positive and highly significant ($\beta = 0.361$, $p < 0.001$, 95% CI [0.307, 0.408]), indicating that higher levels of knowledge transfer within the ecosystem are associated with increased availability or perceived sufficiency of entrepreneurial financing. This finding supports H1.

H1. *R&D Level of Transference significantly and positively influences the Sufficiency of Financing for Entrepreneurs, according to our results.*

The path from Sufficiency of Financing for Entrepreneurs to TECHTEA is also positive and statistically significant ($\beta = 0.117$, $p < 0.001$, 95% CI [0.060, 0.176]), supporting H2. However, the magnitude of this effect is relatively small, suggesting that while financing is a necessary condition, it is not a sufficiently strong driver of technological entrepreneurial activity in emerging markets.

H2. *The Sufficiency of Financing for Entrepreneurs has a significant and positive influence on Technological Total Entrepreneurial Activity, according to our results.*

In contrast, the direct effect of R&D transfer on TechTEA is negative and significant ($\beta = -0.070$, $p = 0.018$, 95% CI [−0.125, −0.015]). H3 is rejected in this research.

H3. *R&D Level of Transference does a negative influence on Technological Total Entrepreneurial Activity according to our results.*

Table 6. Direct effects.

Associations	Path Coefficients	Lower CI	Upper CI	P Values
R&D Level of Transfer -> Sufficiency of Financing for Entrepreneurs	0.361	0.307	0.408	0.000
Sufficiency of Financing for Entrepreneurs -> TECHTEA	0.117	0.060	0.176	0.000
R&D Level of Transfer -> TECHTEA	−0.070	−0.125	−0.015	0.018

5.3.3. Mediation Analysis

To further examine the underlying mechanisms linking the independent and dependent variables, a mediation analysis was conducted. This analysis aims to disentangle the direct and indirect effects among the constructs and to assess whether the relationship under study operates through an intervening variable.

Inconsistent Mediation

The exploratory results confirm this inconsistent mediation. First, as displayed in Table 7, the specific indirect effect of the R&D Level of Transfer on TECHTEA, mediated by the Sufficiency of Financing for Entrepreneurs, is positive and statistically significant ($\beta = 0.042$, $p < 0.001$, 95% CI [0.022, 0.065]).

Table 7. Mediation effect.

Associations	Total Indirect Effects	Lower CI	Upper CI	P Values
R&D Level of Transfer -> Sufficiency of Financing for Entrepreneurs -> TECHTEA	0.042	0.022	0.065	0.001

The direct effect of the R&D Level of Transfer on TechTEA (the relationship that remains while the mediator is in the model) is -0.070 (see Table 4). This path is statistically significant, as evidenced by a p -value of 0.198 and a 95% bias-corrected bootstrap confidence interval $[-0.082, 0.025]$ as detailed in Table 7.

H4. *The Sufficiency of Financing for Entrepreneurship inconsistently mediates the relationship between the R&D Level of Transfer and Technological Total Entrepreneurial Activity (TechTEA).*

Because the direct effect is negative ($\beta = -0.070$) while the specific indirect pathway is positive ($\beta = 0.042$), the opposite signs satisfy the mathematical criteria for an inconsistent mediation. Given the exploratory nature of this study, these results demonstrate that the positive indirect pathway via financing offsets the negative direct pressure of isolated R&D investments. As noted by MacKinnon et al. (2000) [59], this internal cancelation drives the standardized total effect of the R&D Level of Transfer on TechTEA closer to zero ($\beta = -0.028$, $p > 0.001$, 95% CI $[-0.082, 0.025]$).

5.3.4. Model Explanatory Power and Effect Sizes

The explanatory power of a structural model is assessed by the coefficient of determination R^2 , which represents the proportion of variance in an endogenous (dependent) construct explained by its predictors.

- Sufficiency of Financing for Entrepreneurs ($R^2 = 0.130$): This value indicates that the R&D Level of Transfer explains 13% of the variance in Sufficiency of Financing for

Entrepreneurs. According to common rules of thumb in PLS-SEM (e.g., [60]), R^2 values of 0.67, 0.33, and 0.19 are considered substantial, moderate, and weak, respectively. Therefore, the explanatory power for Financing is weak.

- TechTEA ($R^2 = 0.015$): This result shows that Sufficiency of Financing for Entrepreneurs and R&D Level of Transfer combined explain only 1.5% of the variance in TECHTEA. This level of explanation is considered very weak, falling significantly below the 0.19 threshold for weak predictive power.

5.3.5. Effect Sizes f^2

The effect size f^2 measures the substantive impact of a specific independent construct on a dependent construct by evaluating how much the R^2 changes when that predictor is omitted. Following Cohen's (1988) [61] definitions, f^2 values of 0.02, 0.15, and 0.35 represent small, medium, and large effects, respectively.

- R&D Level of Transfer $\rightarrow$ Sufficiency of Financing for Entrepreneurs ($f^2 = 0.150$): This indicates that R&D has a medium effect on the variance explained in Financing. This is the most substantive relationship in this structural model.
- Sufficiency of Financing for Entrepreneurs $\rightarrow$ TechTEA ($f^2 = 0.013$): This value is below the 0.02 threshold, indicating that Financing has a very weak effect on the explanatory power of TechTEA.
- R&D Level of Transfer $\rightarrow$ TechTEA ($f^2 = 0.004$): This result represents a negligible effect. This reinforces the previous mediation analysis finding that the direct path from R&D to TechTEA is not statistically significant and contributes almost nothing to the model's explanatory power.

While the model shows that R&D transfer has a significant effect on Financing, the overall explanatory power for the final dependent variable is very low ($R^2 = 0.015$). This indicates that our proposed variables explain only 1.5% of the variance in TechTEA, suggesting that the remaining 98.5% is driven by unobserved external factors. Given the exploratory nature of this study, this low variance highlights that TechTEA is influenced by other omitted determinants in emerging markets, such as institutional quality (e.g., intellectual property protection rules and judicial efficiency), firm-level absorptive capacity, a risk averse entrepreneurial culture, low national digital maturity, and capital market development.

6. Discussion

This study provides empirical evidence on the structural mechanisms that underpin technological entrepreneurial activity (TechTEA) in emerging economies, advancing the Extended Resource-Based View (RBV) applied to entrepreneurial ecosystems by disentangling the interdependencies between knowledge-based resources (the R&D Level of Transfer) and financial resources (the Sufficiency of Financing for Entrepreneurs). The results reveal a non-linear relationship characterized by inefficiencies that fundamentally challenge dominant assumptions in the literature [62–64].

6.1. The Limits of Traditional Theory: Interpreting the Low Explanatory Power

A critical starting point for interpreting our structural model is its highly constrained explanatory power. This low variance delivers the most profound diagnostic insight of this study, directly disrupting the status quo in the technological entrepreneurship literature regarding its universal applicability to emerging economies. Traditional, Western-centric frameworks implicitly assume that a straightforward pipeline combining technical knowledge inputs and capital injections is the primary, self-sufficient driver of high-tech venture creation [25,39,40].

Our results fundamentally challenge this baseline assumption, demonstrating that these conventional benchmarks explain merely 1.5% of the total variance in TechTEA across 26 emerging markets. This discrepancy implies that in environments characterized by deep institutional voids, raw resource endowments are secondary. The fact that 98.5% of the variance remains unexplained delivers empirical evidence that technological entrepreneurship in these regions is governed by an entirely different, decentralized matrix of unobserved external factors. As suggested by Lu and Deng (2025) [65], external knowledge and investment only stimulate tech startups when a robust, multi-layered institutional framework reduces risk and systemic friction.

6.2. Interpreting the Friction of R&D in Emerging Economies

Within this context of systemic fragmentation, our exploratory findings indicate that the knowledge-based resource does not exert a uniformly positive effect. While R&D transfer significantly enhances the availability of complementary financial resources ($\text{Beta} = 0.361, p < 0.001$), its direct effect on TechTEA is negative and statistically significant ($\text{Beta} = -0.070, p = 0.018$). This paradoxical relationship indicates that the mere generation or transfer of technology introduces systemic friction.

From an Extended RBV standpoint, this negative direct effect can be interpreted as evidence of knowledge creation without commercialization capacity, where technological advancements accumulate as an institutional liability rather than a catalyst [40,44]. This breakdown often stems from a lack of user path convergence. According to Swanson (2024, p. 10) [46], the “absence of path convergence may explain why a technology fails to be taken up as expected despite the promotional efforts of technology entrepreneurs.” On one hand, devices and innovations may not be up to the tasks envisioned due to researchers prioritizing scientific logic over commercial ones. On the other hand, targeted users in emerging economies often have insufficient motivation to adapt their practices to the tools offered, particularly if the wider ecosystem lacks what Swanson and Ramiller (1997) [46] define as a clear organizing vision to help stakeholders make sense of new technologies.

6.3. Financial Resources and Inconsistent Mediation

This profound mismatch explains why the transmission mechanism of capital remains highly constrained. While the financial resource shows a positive relationship with TechTEA, the relatively small magnitude of this direct effect ($\text{Beta} = 0.117, p < 0.001$) confirms a fundamental inefficiency in how capital translates into outcomes. Analyzing the qualitative nature of the relationship between founders and funders explains this constraint. As argued by Muñoz et al. (2023) [62], financing frequently occurs within a rigid transactional framework where investors prioritize immediate profits. This stalls the initial flexibility required for a technology startup to pivot and discover its market [24,63]. Furthermore, venture capitalists and angel investors in emerging markets tend to focus on immediate market adoption, yet adoption remains limited due to gaps in critical capabilities and skills needed to scale such products [37]. This is echoed by technology transfer programs like I-Corps, where its co-founder, Errol Arkilic, notes that the failure of many ventures backed by government grants (like SBIR) occurs because scientists use capital to build things that nobody cares about due to an absolute lack of market understanding [64]. Consequently, this structural misalignment underpins our identified inconsistent mediation mechanism, or suppression dynamic. The indirect path of the knowledge-based resource on TechTEA through financing is positive and significant ($\text{Beta} = 0.042, p = 0.001$), while the direct effect remains negative ($\text{Beta} = -0.070$). Rather than acting as a traditional growth multiplier, the financial resource functions merely as an emergency institutional buffer.

Financing is required not to accelerate scaling, but to statistically counterweight, neutralize, and rescue the inherent risks and frictions generated by uncoordinated technology transfer.

7. Conclusions

Regarding the model's overall explanatory power, the defining contribution of this study lies in demonstrating that the principles of the Resource-Based View (RBV) operate in a fundamentally distinct manner within emerging economies compared to advanced markets. Our results challenge the status quo of the traditional literature by offering empirical proof that the conventional RBV assumption—which dictates that combining traditional knowledge assets (R&D transfer) and capital injections (sufficiency of financing) is a self-sufficient driver of high-tech ventures—does not hold true in developing contexts. This stark mismatch highlights a critical challenge for ecosystem sustainability: the absence of a comprehensive institutional framework prevents the Triple Bottom Line from being fully realized, as technological potential struggles to achieve the economic viability necessary for long-term societal impact (Elkington, 1997) [2]. Consequently, these insights suggest that under an emerging-market RBV logic, policymakers cannot rely on isolated asset injections. Instead, future strategies must pivot toward comprehensive ecosystem orchestration—prioritizing institutional friction-reduction mechanisms, unified regulatory governance, and firm-level absorptive capacity—to allow technological ventures to scale and survive over time.

At the variable level, the structural relationships within our model explain the specific mechanisms behind this friction. Grounded in this Extended RBV for entrepreneurial ecosystems, our exploratory model reveals that the isolated transfer of knowledge-based resources plays a counterproductive role, directly introducing systemic friction that can constrain active venture creation. While efforts in knowledge transfer do significantly increase the availability of complementary financial resources, financing does not act as a traditional growth multiplier in these environments. Instead, it functions merely as an emergency institutional buffer—a structural counterweight required to neutralize the negative direct friction of R&D and unlock its latent indirect potential. From a sustainability perspective, understanding this micro-level tension is vital to ensure that intellectual capital is not wasted, aligning with the principle of efficient resource use proposed by the World Commission on Environment and Development (1987) [1] to allow technological ventures to survive, counterbalance structural risk, and scale over time.

7.1. Theoretical Implications

A critical starting point for the explorative theoretical implications of this study is our model's constrained explanatory power. Traditional, Western-centric frameworks operate under the implicit assumption that a combination of knowledge-based resources (R&D transfer) and financial resources is the primary, self-sufficient driver of high-tech ventures [25,39,40]. Our results disrupt this baseline assumption, delivering a profound diagnostic insight: in emerging economies, simply injecting R&D and financing does not guarantee technological entrepreneurship. The fact that 98.5% of the variance remains unexplained proves that widespread macro-level TechTEA depends on a much broader, decentralized matrix of unobserved institutional governance, regulatory quality, and market alignment that extends far beyond the traditional resource variables isolated in standard models [26].

Rather than showing a classical positive synergy or a simple full mediation, our exploratory analysis reveals that the knowledge-based resource (R&D transfer) introduces negative direct friction. However, this negative path is statistically counterweighted and suppressed by the positive indirect pathway of the complementary financial resource.

When viewed through the lens of the Extended Resource-Based View (RBV) applied to entrepreneurial ecosystems, this suppression dynamic serves as an empirical manifestation of structural tension in developing contexts. Traditionally, the EE literature suggests that environmental pillars function as bundles of complementary assets requiring mutual mobilization [15,16]. Our findings refine this logic for emerging economies: an isolated knowledge resource (R&D transfer) represents raw market potential that acts as an institutional liability—generating friction and bottlenecks—unless it is effectively backed by a complementary financial resource to act as an absorptive bridge. Theoretically, this indicates that financing does not function as a growth multiplier in these entrepreneurial ecosystems, but rather as a localized, defensive institutional buffer required merely to neutralize the inherent risks of uncoordinated technology transfer. This study demonstrates that resource complementarity in emerging economies is an intensely conditional process where traditional resource availability is secondary to broader ecosystem orchestration.

7.2. Practical Implications

The discussion on entrepreneurial ecosystems has traditionally focused on mere resource accumulation. However, our exploratory findings indicate that resources such as R&D transfer and financing are insufficient on their own; their efficacy is dependent upon the institutional architecture and the specific conversion mechanisms that connect research institutions, investors, entrepreneurs, and markets. To translate these exploratory trends into actionable insights, the implications are categorized into three systemic levels.

7.2.1. Policy Implications

Public policy must shift away from isolated resources injections and focus on establishing a cohesive, multi-branch institutional architecture where government agencies act as ecosystem orchestrators rather than simple funding providers [66]. Grounded in the necessity of cross-sector coherence [67], governments should deploy three concrete, actionable instruments:

- **Inter-Ministerial Policy Integration:** National governments should establish a centralized inter-ministerial council to align industrial, educational, and financial regulations. This mechanism explicitly prevents structural contradictions where one public agency subsidizes academic R&D while another maintains bureaucratic hurdles that stifle technological venture registration or private capital mobilization.
- **Institutional Risk-Mitigation Infrastructure:** To convert risk-averse capital into active early-stage investment, policymakers must strengthen intellectual property (IP) protection and accelerate contract enforcement protocols. Public governance must provide legal certainty to ensure that private investors can confidently back high-risk, technology-based startups.
- **Co-Investment and Market-Linking Programs:** State agencies should operationalize coordinated governance by implementing public–private seed funds and matching grants designed to explicitly de-risk early-stage private equity. Additionally, following successful international benchmarks, public policies should mandate university–industry commercialization programs that actively connect technology-based ventures with international markets from inception, effectively bypassing small or underdeveloped domestic demand constraints [4].

7.2.2. Managerial Implications for Universities and Technology Transfer Offices (TTOs)

For universities and TTOs, the traditional focus on securing patents must shift toward market validation and ecosystem orchestration. R&D transfer yields localized value only

when accompanied by specialized cognitive and managerial support to overcome the absence of commercialization mechanisms.

TTO managers should implement structured customer-discovery programs (such as Lean LaunchPad methodologies) to ensure that laboratory technologies align with actual market needs before deploying capital. Additionally, universities must establish dedicated IP commercialization offices that operate with corporate flexibility rather than academic bureaucracy. To bridge the gap caused by limited human capital and specialized skills in small ventures, TTOs should actively collaborate with venture studios and venture builders. These emerging actors play a key role in selecting new venture projects, evaluating technological initiatives, and injecting the strategic, complementary managerial capabilities needed to structure scientific projects into viable businesses [68].

7.2.3. Investment Implications for Venture Capital and Angel Networks

Our exploratory finding regarding the inconsistent mediation effect underscores that financial capital cannot act as a blind resource; it must function as an absorptive bridge. For angel networks and venture capital (VC) firms in emerging markets, this requires moving away from traditional collateral-based lending or late-stage investing, and moving toward accelerator-linked investment models.

Investors should deploy early-stage proof-of-concept (PoC) funding to test the commercial viability of high-tech academic spin-offs. Furthermore, the relationship between entrepreneurs and investors requires initial flexibility to allow startups to pivot and discover their markets. Aligning the strategic objectives of both parties is essential to balance investors' return expectations with the technological and sustainable impact pursued by the entrepreneurs [37,63]. Financing mechanisms must allow startups the operational room to navigate conflicting goals during their initial growth phase, transforming raw technology into sustainable market value.

7.3. Limitations

The primary limitation of this study lies in its reliance on cross-sectional data. Future research using longitudinal data could provide deeper insights into how R&D transfer and financing influence technological entrepreneurial activity over time. A longitudinal perspective is particularly important given the extended time horizons required for technological development to reach market readiness.

One limitation of this study is its exclusive focus on the resource provision component of the entrepreneurial ecosystem. While isolating this specific dimension allowed for a precise analysis of resource interdependence, a broader, more holistic perspective of the phenomenon could provide a more comprehensive understanding of the entrepreneurial ecosystem in emerging economies. Future research should integrate other systemic pillars—such as cultural norms and entrepreneurial connectors—to capture the full complexity of these developing environments.

A limitation of this study is the risk of systematic bias when utilizing expert surveys rather than objective indicators of formal financing availability and R&D transfer. The omission of a robustness test like adding traditional macroeconomic control variables reflects a broader, structural limitation within the field: standardized global datasets, such as those from the World Bank, still lack consistent and complete indicators for all the emerging economies included in our sample. Furthermore, as highlighted by Acs et al. (2008) [48], official national data sources differ significantly in how they define core economic variables, rendering cross-country controls, for example in real financing availability, highly problematic and conceptually incompatible.

While the GEM framework effectively bypasses these national bureaucratic inconsistencies by applying a uniform, harmonized measurement infrastructure, we acknowledge that the necessary granular data to perfectly control for these dynamics is not yet fully available. Nevertheless, it is critical not to paralyze research due to these institutional data gaps. Presenting exploratory studies in emerging economies is a necessary and urgent point of departure; waiting for flawless macroeconomic data would mean systematically excluding these vulnerable ecosystems from the academic literature. Therefore, this exploratory model establishes an essential baseline so that future research can implement advanced robustness checks as data infrastructure matures in these developing nations.

Additionally, the study relies on expert perceptions within each entrepreneurial ecosystem. Future research could incorporate more objective, directly observable measures, such as investment in technology firms, startup debt levels, R&D activity volumes, and patent counts, to more accurately capture the variables of interest.

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