

Exploring the Relationship between Infrastructure and Entrepreneurial Development in BRICS Countries « PMG-ARDL » approach

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Abstract. This article examines the significance of infrastructure in the emergence and development of entrepreneurship, focusing on policies and their interaction with other public support programs. The central issue is to emphasize the importance of considering various types and specificities of infrastructure. The article posits multiple hypotheses regarding the impact of infrastructure on entrepreneurship, with an emphasis on long-term influence. It assumes that incorporating infrastructure into public policies is essential for fostering entrepreneurial growth. Additionally, it suggests that diverse types of infrastructure play a crucial role in the development of an entrepreneurial ecosystem, particularly in technology sectors.

The methodology employed in this study is based on the PMG-ARDL method. Researchers used the "TEA" proxy to measure entrepreneurial dynamics and examine the impact of specific infrastructure characteristics. The sample consists of data from BRICS countries, enabling comparisons across institutional contexts and development levels.

The main contributions of this study lie in highlighting the importance of infrastructure for entrepreneurship, especially in the long term. Results suggest that public policies should pay special attention to planning and improving infrastructure to energize the entrepreneurial ecosystem. The research also underscores the need for developing new indices to better measure the various specificities of infrastructure.

1. Introduction

The determinants of access to entrepreneurship have been studied for decades, examining the various circumstances that facilitate or hinder the emergence and development of TEA [1]. In the quest to understand special disparities in terms of entrepreneurial activities, the focus of studies has shifted from the individual (the entrepreneur) to the regional and/or national level [2, 3]. Space, as a determinant in terms of entrepreneurial opportunities, is increasingly present in scientific research [3]. The work of [4] advocates for the multidimensional spatial influences on entrepreneurial activity. Infrastructure (physical) is an important component of the entrepreneurial space, but it has not been addressed as such until the second decade of the 21st century [5].

Infrastructure promotes the development of entrepreneurial opportunities and the capacity for creating a new business to seize these opportunities. Thus, infrastructure acts as a catalyst for economic processes, particularly through the generation of entrepreneurial opportunities [6, 7]. Indeed, numerous contributions in the literature have reported relevant empirical evidence linking infrastructure to economic growth [7]. This supports the legitimacy of studying the relationship between infrastructure and the dynamics of entrepreneurial activity. This falls within the scope of analyzing the role of the entrepreneurial ecosystem in entrepreneurial decision-making. The regional or spatial context has been extensively covered in the literature [4, 8-10], but infrastructure has not been studied as one of the determinants of entrepreneurial decision-making.

The main objective of this research is to analyze the impact of infrastructure on Total Early-stage Entrepreneurial Activity (TEA). We examine physical infrastructure on one hand, and commercial, legal, and professional infrastructure on the other hand. Other control variables are added to our econometric model. These include support programs and government support for entrepreneurship, as well as the variable of entrepreneurial project financing.

The paper will be organized into four sections: the first will present the literature review and the hypotheses derived from it. The second section will focus on the methodology and research data. The third section will present the econometric results, and the fourth section will discuss the implications of this research.

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2. Literature

In this theoretical part of our scientific article, we will thoroughly examine the impact of the entrepreneurial ecosystem and infrastructure on Total Early-stage Entrepreneurial Activity (TEA). We will discuss the main theoretical contributions related to the entrepreneurial ecosystem and infrastructure, highlighting the mechanisms through which they can influence entrepreneurship. However, before that, we will treat TEA as a measurement proxy for entrepreneurial dynamics widely adopted by scientific research

2.1 *Le TEA as A Proxy for Entrepreneurship*

The examination of the emergence of entrepreneurial activities and their intricate dynamics in relation to their determinants has been explored by numerous authors. It is important to note that each approach has its own merits and can be adjusted according to specific research objectives. Some researchers may prefer an approach that focuses on specific factors, while others may choose a more holistic approach like the Global Entrepreneurship Monitor (GEM). A thorough comprehension of these different approaches enhances the formulation of entrepreneurial measures and provides complementary perspectives on entrepreneurial dynamics. In this study, we have opted to adopt the GEM approach and will justify our decision through a comparison with other approaches presented by [11-13] as well as [14]. The GEM approach concentrates on measuring the level of entrepreneurial activity (TEA) within a particular geographical entity over a defined period. TEA is computed by considering the proportion of the adult population involved in initiating or managing a new business for less than three and a half years. This approach encompasses various determinant factors, such as financing, government policies, specific programs, education and training, market openness, socio-cultural norms, technology transfer and research and development, as well as physical, legal, and commercial infrastructure. The GEM approach distinguishes itself through its comprehensive nature, providing a holistic view of entrepreneurial dynamics, unlike other approaches that focus more on specific factors.

For example, [11] consider that the creation of a business itself explains entrepreneurial dynamics, while [12] also take into account business creation, public actions, and the positive effect of unemployment. These approaches emphasize business creation as a key determinant of entrepreneurial activities' dynamics.

[13], while adopting the GEM definition, proposes a more specific list of determining factors, including public infrastructure and financing structures, the proportion of self-employed individuals in the population aged 20 and above, the specialization index in high-tech industries, unemployment rate, firm size, and diversity of the productive system.

[14] adopt a broader approach by defining entrepreneurial dynamics as a multidimensional measure of entrepreneurial activity, encompassing not only business creation but also development, growth, and recovery. Their determining factors include the entrepreneurial infrastructure of business support services, strategic governance for entrepreneurial dynamism, as well as physical and intangible infrastructure.

2.2 *Entrepreneurship, Entrepreneurial Ecosystem, and Infrastructure: Theory & Hypotheses*

The quality and quantity of entrepreneurial dynamics in a region result from different combinations of factors along various composite paths. Configurations of interdependent heterogeneous factors can influence entrepreneurial dynamics, especially in urban areas [15]. Hence, the search for an integrated analytical model that explores the mechanisms through which environmental factors affect entrepreneurship, taking into account both quantity and quality aspects. The entrepreneurial ecosystem is a model that has attracted a significant portion of entrepreneurship researchers. Therefore, by adopting a holistic approach to better understand entrepreneurship, and following the example of [16], proponents of the entrepreneurial ecosystem concept start from the idea that entrepreneurship is part of a larger economic ecosystem and cannot be studied as an isolated event. They focus on the concept of the entrepreneurial ecosystem to refer to a framework that explains how institutional and socio-economic characteristics influence entrepreneurship [17].

A rich body of literature exists on the basic framework of the entrepreneurial ecosystem [8]. However, in the following section of our research, we adhere to this holistic approach by adopting the definition of [18], who define the entrepreneurial ecosystem as a set of "institutional, organizational, and systemic factors, as well as other factors, that interact and influence the identification and commercialization of entrepreneurial opportunities."

The key elements that have achieved academic consensus in supporting entrepreneurship can be summarized in four main areas: physical, commercial, and professional infrastructure; innovation capacity and market potential [19]; [20]; human and financial capital; government size [21].

Infrastructure is an essential pillar for the entire dynamics of the entrepreneurial ecosystem. It interacts with all components of the ecosystem, strengthening various factors and contributing to their contributions to economic growth through entrepreneurship. Similarly, by improving the accessibility, reliability, and quality of infrastructure, governments and key stakeholders can create an environment conducive to entrepreneurship, thereby fostering the

creation and growth of businesses. The same entrepreneurial outcomes could result from several combinations of pathways [22]. Dynamics and complexity are the main characteristics of elements within the entrepreneurial ecosystem. In fact, a bidirectional dynamic exists between infrastructure and market potential. On one hand, as emphasized by [23], convenient infrastructure is attractive to the workforce. On the other hand, an increase in the workforce leads to a larger market potential due to population growth. Consequently, a high demand for physical infrastructure becomes inevitable. Physical infrastructure and the Internet are closely linked as well. Thus, according to [24], the increase in attracted workforce can generate economies of scale, which can boost investments in Internet infrastructure. Simultaneously, well-defined property rights, reliable accounting and legal services form the basis of a commercial infrastructure that ensures the security of business transactions, encourages investment in research and development (R&D), and stimulates innovation to create new business opportunities and develop competitive new products and/or services.

Policies and government support programs that provide direct assistance to entrepreneurs and strengthen the entrepreneurial ecosystem can only be achieved with high-quality infrastructure at both regional and national levels. The size of government expenditures at this level is a determining institutional factor, hence the integration of the government size variable that reflects the level of government intervention in entrepreneurship indirectly through education, taxation, and policies, among others [21]. Therefore, within this framework, we are separately studying:

- Government support: This dimension concerns government policies that support entrepreneurship and recognize its significance as a relevant economic issue. This includes the degree of support from public policies for entrepreneurship and the importance given to this issue.
- Government entrepreneurship programs: This dimension evaluates the presence and quality of specific programs implemented by governments (national, regional, municipal) to directly assist SMEs. The focus is on measuring the effectiveness and accessibility of these assistance programs.

2.3 Research Hypotheses

Hypothesis 1: There is a positive relationship between entrepreneurial finance and TEA.

Hypothesis 2: Government policies supporting entrepreneurship have a positive impact on TEA.

Hypothesis 3: Government entrepreneurship programs have a positive influence on TEA.

Hypothesis 4: A strong business and legal infrastructure promotes TEA.

Hypothesis 5: Adequate physical infrastructure is associated with a high level of TEA.

3. Data & Methodology

Our objective was to adopt a comprehensive perspective and gain a better understanding of the causal relationships between variables in the entrepreneurial ecosystem through the use of panel data, which offer a broad spectrum of analysis. Similarly, our quest for relevant and reliable data on our variables led us to the global survey data provided by the Global Entrepreneurship Monitor (GEM). Widely utilized in entrepreneurship research, GEM serves as a valuable source of detailed information on entrepreneur characteristics, entrepreneurial attitudes, institutional factors, and variables related to the business environment. Researchers can examine how these selected variables evolve over time, identify differences between countries and regions, and assess the impact of these variables on the entrepreneurial activity rate (TEA). This is made possible by international coverage, longitudinal data, a robust methodology, and specific variables that are available. These ingredients serve to enhance the robustness and relevance of the results, allowing for comparisons of findings with other studies conducted in various countries and contexts.

3.1 Variables

Entrepreneurial finance: The availability of financial resources is crucial to support small and medium-sized enterprises (SMEs). Businesses require equity and debt capital to start their operations, invest in innovation, purchase equipment, and finance their growth. Entrepreneurial finance enables entrepreneurs to access the necessary funds to realize their business projects, and its importance is well-documented in the academic literature [25].

- Government support: Government policies play a crucial role in promoting entrepreneurship as a relevant economic issue. Appropriate support policies can stimulate business creation, facilitate access to resources, reduce entry barriers, and encourage innovation. On the other hand, high taxes and excessive bureaucracy can hinder entrepreneurial activity and limit business growth. Numerous studies have examined the impact of government policies on entrepreneurship and emphasized their importance in fostering an entrepreneur-friendly environment [26].
- Government entrepreneurship programs: Direct assistance programs for SMEs can play a crucial role in supporting entrepreneurs and enhancing their capacity for success. These programs offer a wide range of services, such as management advice, training, financing, and business incubators. They help reduce the risks associated with business creation and development, and provide entrepreneurs with practical support and resources to overcome the challenges they face [3].
- Commercial and legal infrastructure: Strong infrastructure is essential to support businesses, particularly SMEs. Adequate protection of property rights, accessible commercial, accounting, and legal services, as well as SME-friendly

institutions, are key elements in fostering entrepreneurial activity. Well-developed commercial and legal infrastructure facilitates business creation, enhances investor confidence, and promotes innovation [33]; [27].

- Physical infrastructure: Physical infrastructure, such as communication infrastructure, utilities, transportation, and commercial spaces, is indispensable for the smooth functioning of businesses. Entrepreneurs need easy and affordable access to these resources to conduct their business activities. Well-developed physical infrastructure promotes connectivity, the mobility of goods and people, and creates an environment conducive to entrepreneurship. Numerous studies have emphasized the importance of physical infrastructure for business growth and entrepreneurial activity [28, 29].

3.2 "BRICS" Countries as the Sample

The economic and developmental similarities, regional relevance, data accessibility, and international visibility are the reasons that motivated us to utilize the BRICS countries as a benchmark for developing countries in the study of the relationship between infrastructure investments and entrepreneurship. This is done with the aim of drawing lessons from the policies and practices of BRICS countries and adapting these insights to the specific context of developing countries for better promotion of entrepreneurship and efficient utilization of infrastructure investments. The contribution of each sample characteristic to the quality of our research is illustrated as follows:

- Economic and Developmental Similarities.
- Regional Relevance.
- Accessible Data.
- International Visibility.

3.3 The PMG-ARDL Method

The objective of our research is to gain a better understanding of the factors that influence entrepreneurship and develop more effective policies to promote it. To capture the dynamic relationships between the variables under study with robust empirical results, we have adopted the PMG-ARDL method. This choice is based on the following reasons:

- Panel data: Given that the study focuses on entrepreneurship and its determinants, it is important to consider the temporal and cross-sectional dimensions of the data. Panel data, which combines information on multiple individual units observed over multiple time periods, allows us to capture variations at both the individual and temporal levels. This enables us to obtain more robust estimates and better grasp the dynamics of entrepreneurship.
- Dynamic structure: The PMG-ARDL method allows for modeling the dynamic relationships between variables, taking into account the presence of lags and long-term effects. The Autoregressive Distributed Lag (ARDL) captures short-term relationships, while the Vector Autoregressive (VAR) considers long-term relationships. This dynamic structure allows us to explore causal links between variables and understand how shocks or changes in one variable can affect other variables in the system.
- Controlling for individual effects and heterogeneity: The PMG-ARDL model allows for controlling individual effects specific to each panel unit, thereby accounting for differences among countries, regions, or firms. By controlling for these individual effects, it is possible to better isolate the effect of explanatory variables on entrepreneurship, reducing the risk of bias caused by unobserved individual factors.
- Cointegration consideration: The PMG-ARDL method is particularly suitable when variables are cointegrated, meaning they have a stable long-term relationship. This property is important as it helps identify long-term relationships between variables and estimate the long-term effects of entrepreneurship determinants. Additionally, the PMG-ARDL method also allows for analyzing short-term adjustments around the long-term relationship.
- Robustness to endogeneity issues: Estimating through the PMG-ARDL method helps address endogeneity problems often present in entrepreneurship studies. By controlling for individual effects specific to each panel unit and using appropriate instrumental variables, it is possible to reduce the risk of endogeneity and obtain more reliable and consistent estimates.

4. Empirical results

4.1 Descriptive Statistics & stationarity

According to the information from the descriptive statistics (Table 1), we observe that the independent variables have a low deviation (indicating a low dispersion of data): PHS_INFR (0.462973); INFR_CP (0.323548); GUVSUP (0.492897); GOVPROG (0.360512); and FINC (0.438359). The variable TEA displays a slightly higher standard deviation. Regarding the distribution of variables, only the variables INFR_CP and GOVPROG do not appear to follow a normal distribution, as indicated by their Jarque-Bera statistics and probabilities below 0.05. This suggests a significant deviation from normality. On the other hand, the other variables seem to follow a distribution close to the normal distribution, as they have a skewness value close to zero and a kurtosis value close to 3. Furthermore, their Jarque-Bera statistics have high probabilities, indicating a good fit to the normal distribution.

	Skewness	Kurtosis	P_value
TEA_	0.48	2.72	0.18
PHS_INFR	0.04	2.67	0.82
INFR_CP	0.91	4.30	0.00
GUVSUP	0.27	2.24	0.22
GOVPROG	0.84	3.34	0.00
FINC	0.30	2.62	0.42

Table 1: Descriptive Statistics

The table of the PP unit root test (Table 2) provides the results of variable stationarity. At the level, all variables exhibit a non-stationary behavior when tested without a constant term, with a constant term, and even with a constant term and trend. Additionally, when differenced once, all variables demonstrate stationary behavior according to the PP test with a 5% threshold.

UNIT ROOT TEST TABLE (PP)					
TEA_	PHS_INFR	INFR_CP	GUVSUP	GOVPROG	FINC
I(1)	I(1)	I(1)	I(1)	I(1)	I(1)

Table 2: Variables stationarity (PP Test)

4.2 Long & short Run Equations

In a PMG-ARDL model, the long-term results (Table 3), also known as long-term coefficients, measure the long-term effects of exogenous variables on the dependent variable, which in our case is TEA. The results in this part of the model indicate two types of relationships: directly proportional relationships (positive and significant coefficients) and inversely proportional relationships (negative and significant coefficients). Thus, holding everything else constant, the interpretation of the long-term coefficients for the independent variables suggests that for the variable PHS_INFR, the coefficient of 2.459137 suggests that an increase of one unit in this variable leads to an increase of 2.459137 units in TEA in the long term. For the variable INFR_CP, the coefficient of -4.342304 indicates that an increase of one unit in this variable leads to a decrease of 4.342304 units in TEA in the long term (relationship is inversely proportional). As for the coefficient of the variable GUVSUP, it is approximately -8.188926. This means that an increase of one unit in this variable leads to a decrease of 8.188926 units in TEA in the long term, indicating an inversely proportional relationship for this variable. The variable GOVPROG has a coefficient of 3.973714, which means that an increase of one unit in this variable leads to an increase of 3.973714 units in TEA in the long term, holding everything else constant. For the variable FINC, the coefficient of 2.447599 indicates that an increase of one unit in the FINC variable leads to an increase of 2.447599 units in TEA in the long term, holding everything else constant.

	Coefficient	Std. Error	t-Statistic	Prob.*
Long Run Equation				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
PHS_INFR	2.45	0.49	4.98	0.0000***
INFR_CP	-4.34	0.82	-5.27	0.0000***
GUVSUP	-8.18	0.51	-15.78	0.0000***
GOVPROG	3.97	1.05	3.75	0.0005***
FINC	2.44	0.54	4.49	0.0001***

Table 3: Long Run coefficients

Noted with the prefix "D" in the short-term equation (Table 4), the explanatory variables are the first differences of the variables. Regarding our dependent variable "TEA," the interpretations of the short-term coefficients indicate that there is cointegration among the variables in this model, as shown by the coefficient of -0.781956 with a significant level (P-value = 0.0165: well below 5%). As for different variables, they are not significant at a 5% threshold, except for the government support variable D(GUVSUP). This variable has a coefficient of 3.777192 with a P-value = 0.0161***. This indicates that an increase of one unit in the variation of the GUVSUP variable leads to an increase of 3.777192 units in TEA in the short term, holding all other factors constant.

Short Run Equation			

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
COINTEQ01	-0.78	0.31	-2.50	0.0165
D(PHS_INFR)	-3.27	2.42	-1.35	0.1841
D(INFR_CP)	2.64	1.88	1.40	0.1686
D(GUVSUP)	3.77	1.50	2.51	0.0161***
D(GOVPROG)	-6.41	3.93	-1.63	0.1107
D(FINC)	-1.49	1.25	-1.18	0.2415
C	15.00	5.48	2.73	0.0092
Mean dependent var	0.08	S.D. dependent var		3.019955
S.E. of regression	2.78	Akaike info criterion		4.272271
Sum squared resid	317.39	Schwarz criterion		5.454715
		Hannan-Quinn criter.		4.746683

Table 4: Short Run coefficients

4.3 Robustness Test

The Jarque-Bera test, which evaluates whether the residuals follow a normal distribution, displays a statistic of 1.81 and a probability of 0.40. A higher Jarque-Bera statistic would indicate a greater deviation from the normal distribution. However, with a relatively low statistic and a probability higher than the significance threshold of 0.05, we do not have sufficient evidence to reject the hypothesis of residual normality. It is important to note that the further analysis of the residual statistics in this PMG-ARDL model suggests that the residuals are generally in line with a normal distribution. Although slight asymmetries and a minor deviation in kurtosis can be observed, these characteristics are minimal and do not significantly indicate a major deviation from normality. Looking at skewness, which measures the asymmetry of the distribution, we find a coefficient of 0.2378. This positive value suggests a slight positive skew, indicating that the residuals may have a slightly higher tendency above the mean. However, such a low skewness value (close to zero) indicates that the distribution of residuals is approximately symmetrical, which is consistent with the assumption of normality. As for kurtosis, which measures the peakedness of the distribution, we obtain a coefficient of 3.589. A value slightly above 3 indicates a slightly sharper distribution than normal. However, the difference is relatively small, suggesting that the residuals exhibit a distribution close to normal.

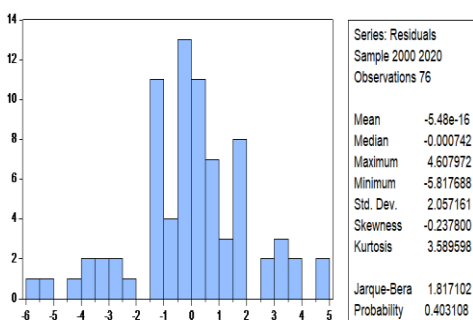


Fig1 : Residuals normality test

To confirm the robustness of our model, a comparison of the graphs of the fitted model in relation to the actual values is visually necessary. Such observation reinforces the notion that the model is appropriate and provides consistent estimations. Indeed, examining the graph of the fitted model in comparison to the actual values indicates a close correspondence between the two, suggesting that the relationships between the independent variables and the dependent variable are well captured. A high visual similarity is observed between the two graphs, indicating that the model is capable of accurately reproducing the variations observed in the real data. As for the residuals, we aim to determine if they are close to zero. Residuals close to zero indicate that the model is capable of explaining most of the variation in the dependent variable using the independent variables included in the model. This also suggests that the residual errors of the model are minimal, further reinforcing the validity of its estimations. The visual similarities between the fitted model and the actual data enhance confidence in the model's ability to accurately predict the dependent variable.

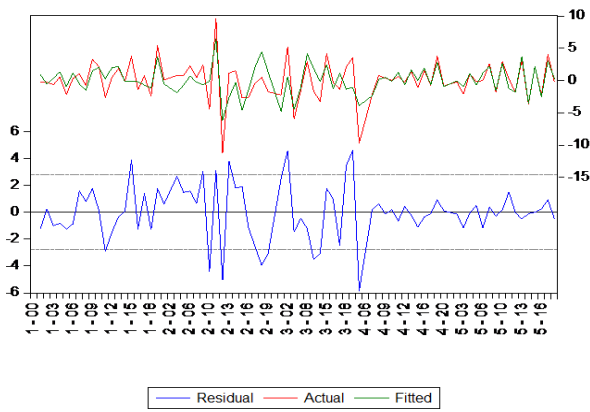


Fig2 : qualité de l'ajustement

5. Discussion & Implications

This study is one of the few research efforts that can examine the meanings of the connections that may exist between infrastructure and TEA (Total Early-stage Entrepreneurial Activity). Overall, it is observed that infrastructure is significantly associated with long-term TEA. However, this association is occasionally inversely proportional (with negative and significant coefficients).

	Long run	Short run	Impact
Hyp 1	Confirmed	Not confirmed	Positive (long run)
Hyp 2	Partially confirmed	Partially confirmed	Negative (long run)
		Positive (short run)	
Hyp3	Confirmed	Not confirmed	Positive (long run)
Hyp 4	Partially confirmed	Not confirmed	Negative (long run)
Hyp5	Confirmed	Not confirmed	Positive (long run)

This justifies taking into account the specificities and type of infrastructure in the analysis. In the context of our sample of BRICS countries, Total Early-Stage Entrepreneurial Activity (TEA) is positively influenced by physical infrastructure but negatively influenced by commercial, legal, and professional infrastructures. It is important to note that these relationships are not significant in the short term, neither at the global nor national level for the countries in our sample. The non-significant results for the short-term coefficients may indicate that it takes time for these infrastructures to significantly influence TEA. The delayed effect of infrastructure is one of the most relevant explanations for this phenomenon. In fact, it is possible that the effects of independent variables on TEA do not manifest in the short term.

In the long term, government support programs do not display the same impact. While support programs show a directly proportional relationship, entrepreneurial support is inversely proportional to TEA. This supports the assumption that the latter supports are related to commercial, legal, and professional infrastructures. In the short term, these same programs were the only variable that showed a directly positive relationship (positive and significant coefficients). This can be justified by the non-sustainability of these programs and/or the lack of proper entrepreneur support in conjunction with these support programs. For example, in some countries, you can only benefit from this support once. Another important point to highlight is that sometimes the development speed of commercial and legal infrastructures does not keep up with the pace of new business models. New business opportunities such as e-commerce rapidly challenge the structure of these infrastructures and also public entrepreneurship support programs. For the other variables, including financial measures, they are not significant. And this is true for both the overall level of our sample and each individual country within it.

6. Conclusion

In future research, it is essential to consider the different types and specificities of infrastructures in the emergence and development of TEA. In terms of public policies, these infrastructures and their interaction with other public programs should be approached from a long-term perspective.

However, it is important to acknowledge a limitation of this study. While we have accounted for two types of infrastructures, there are other types that have not been explicitly measured in our research. Hence, there is a need for new indices and proxies that capture the specificities of different types of infrastructures. This could be a direction for future research, particularly focusing on infrastructure specific to the development of high-tech startups, such as high-speed internet, etc. Additionally, future research could explore the impact of the quality and diversity of infrastructures on the quality of entrepreneurship, specifically in relation to the emergence of startups. These connections should be investigated in other national institutional contexts, especially in less developed countries. The level of development in countries could be a determining factor in the dynamics of other variables within the entrepreneurial ecosystem.

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