Evaluation of Factors Affecting the Innovation Index and Its Synergistic Effects on Economic Growth in Selected Countries

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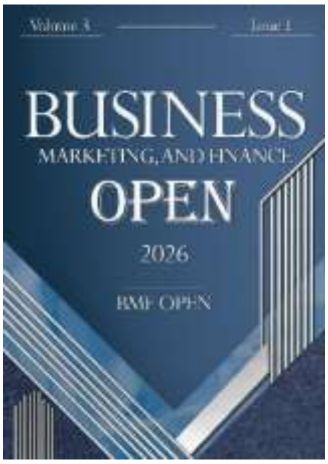

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Abstract: Innovation is the most powerful tool for strengthening national competitiveness in the global economy, and its importance is such that a large part of countries' development is assessed based on their scientific and technological achievements. Accordingly, the present study evaluates the factors influencing innovation, as well as the impact of innovation on economic growth, within the framework of two equations estimated simultaneously during the period 2015–2024 in a set of selected upper-middle-income countries. To estimate the research model, the study employed the system panel data approach using the Generalized Method of Moments (GMM). The findings, at a 95% confidence level, indicate that improvements in global value storage, institutional factors, network readiness, and protection of individual property rights positively affect innovation in the selected countries. Furthermore, the results reveal that improvements in global competitiveness, business environment, economic complexity, and innovation contribute to the increase of economic growth.

Keywords: Innovation Index, Global Value Storage, Global Competitiveness, Economic Complexity

1. Introduction

Innovation has increasingly become a pivotal driver of sustainable economic growth in both developed and developing economies, acting as a catalyst for productivity improvements, industrial upgrading, and competitive advantage [1, 2]. The shift from traditional growth models towards knowledge- and technology-driven paradigms has elevated the role of innovation systems and the interconnectedness of various economic, institutional, and technological factors in fostering growth [3, 4]. In the contemporary global economy, innovation is not only a source of competitive advantage but also a strategic imperative for economic resilience and adaptability in the face of rapid technological change and globalization [5, 6]. Theoretical and empirical evidence suggests that innovation is both a cause and a consequence of economic growth, creating a bidirectional relationship that policy-makers must understand to design effective development strategies [7, 8].

The conceptual foundations of innovation-led growth can be traced to endogenous growth theory, which highlights the role of knowledge accumulation, technological change, and human capital in driving long-term growth [2, 9]. In this framework, innovation enhances productivity by enabling more efficient use of resources, fostering new product development, and creating entirely new markets [10, 11]. In turn, higher economic growth can generate additional resources for investment in research and development (R&D), education, and infrastructure, thereby fueling further innovation [12, 13]. The synergy between innovation and growth underscores the need for robust national innovation systems, which integrate public and private sector capabilities to stimulate technological advancement [4].

The empirical literature emphasizes that the determinants of innovation performance are multifaceted, spanning economic, institutional, and infrastructural dimensions [6, 14]. Factors such as macroeconomic stability, the quality of governance, openness to international trade, and access to finance influence the ability of firms and countries to innovate [3, 15]. Moreover, technological infrastructure—particularly in telecommunications—plays a critical role in enhancing knowledge diffusion, collaboration, and access to global markets [14, 16]. Investment in ICT infrastructure strengthens the absorptive capacity of economies, enabling them to adapt and integrate advanced technologies into their production processes [17, 18].

From a methodological perspective, analyzing the interaction between innovation and economic growth requires rigorous econometric tools capable of capturing dynamic, reciprocal, and spatial interdependencies [17, 19]. Panel data models, particularly dynamic panel approaches, offer substantial advantages in this regard by incorporating both temporal and cross-sectional variation, allowing researchers to control for unobserved heterogeneity and potential endogeneity [20, 21]. The Generalized Method of Moments (GMM) framework is especially useful for addressing endogeneity bias and simultaneity in such models [21, 22]. Furthermore, spatial econometric extensions, including spatial Durbin and spatial dynamic panel models, account for spillover effects that may occur across countries or regions, reflecting the globalized nature of innovation and economic activity [17, 18].

In addition to infrastructure and institutional quality, human capital development is a cornerstone of innovation capacity [5, 11]. Higher levels of education, skill development, and specialized training programs enhance the workforce's ability to generate, absorb, and apply new knowledge [1, 12]. Similarly, foreign direct investment (FDI) can be a powerful channel for technology transfer and innovation diffusion, particularly in developing and emerging economies [8, 9]. However, the benefits of FDI are contingent on the host country's absorptive capacity, which is shaped by its institutional framework, infrastructure, and human capital [3, 7].

Several studies underscore the importance of institutional frameworks in enabling innovation-driven growth [6, 15]. Institutions that enforce property rights, ensure regulatory quality, and maintain transparent legal systems provide the necessary incentives for private investment in innovation [3, 21]. Weak institutions, on the other hand, can hinder R&D activities, discourage entrepreneurial ventures, and exacerbate the risks associated with long-term investment [4, 13]. In this context, innovation policy must be closely aligned with governance reforms to create a conducive environment for technological advancement [5, 6].

Another critical dimension is the role of global value chains (GVCs) in shaping innovation capacity [14, 16]. Participation in GVCs enables countries to access advanced technologies, benefit from knowledge spillovers, and integrate into high-value segments of production networks [1, 17]. These linkages can accelerate innovation through exposure to international best practices, competition, and collaboration with foreign partners [6, 18]. However, maximizing the benefits of GVC participation requires strategic investment in both tangible and intangible assets, including R&D facilities, digital infrastructure, and intellectual property protection [3, 13].

The bidirectional relationship between innovation and economic growth has been extensively documented [2, 7]. On one hand, innovation drives growth by introducing new processes, products, and services that enhance efficiency and competitiveness [1, 10]. On the other hand, economic growth fosters innovation by generating the financial and institutional resources needed for technological development [11, 12]. This virtuous cycle underscores the importance of adopting integrated policies that simultaneously promote innovation capacity and economic expansion [4, 5].

Given these dynamics, it becomes essential to employ empirical models capable of capturing both the direct effects of innovation on growth and the reverse causality from growth to innovation [20, 22]. Dynamic panel models, particularly when estimated using GMM techniques, are well-suited for this purpose [17, 21]. Moreover, the incorporation of spatial dependencies in recent econometric advances reflects the reality that innovation and growth do not occur in isolation but are influenced by regional and global interconnections [18, 19].

In sum, the literature converges on the notion that innovation is a multifactorial process shaped by a country's institutional quality, human capital, infrastructure, and integration into global networks [6, 14]. The interplay between these factors determines the extent to which innovation can contribute to sustained economic growth [2, 10]. This study contributes to this discourse by empirically assessing the determinants of innovation and the bidirectional relationship between innovation and economic growth in selected upper-middle-income countries over the period 2015–2024, employing a dynamic panel system approach with the Generalized Method of Moments.

2. Methodology

The design of the intended model is based on the studies conducted by the researcher in the theoretical literature and previous domestic and international research. Moreover, considering that according to the reviewed studies, the innovation index can be regarded as both a cause and an effect of economic growth, the model is formulated in the form of two equations estimated simultaneously.

The intended model is as follows:

$$EG\_it = \alpha 1 + \alpha 2i\ GC\_it + \alpha 3i\ EB\_it + \alpha 4i\ EC\_it + \alpha 5i\ GI\_it + t + u\_it$$

$$GI\_it = \alpha 1 + \alpha 2i\ GVC\_it + \alpha 3i\ IF\_it + \alpha 4i\ NR\_it + u\_it$$

EG (Economic Growth): Gross Domestic Product (GDP) is a flow variable representing the value of final goods and services produced in a country within a specific time period. It is noteworthy that GDP is measured at constant 2005 prices and expressed in U.S. dollars (World Bank, 2014).

GI (Innovation): Innovation refers to a change in the process of thinking for doing something or creating new things. The data for this variable is the number of patent documents. Given that the patent registration process differs in some countries, for standardization, documents that have been registered globally are considered (World Bank, 2024).

GC (Global Competitiveness): Operational definition: Global competitiveness refers to a country's ability to create and maintain an environment that fosters productivity, development, and sustainable economic growth. The Global Competitiveness Index (GCI) includes criteria such as the quality of institutions, infrastructure, macroeconomic stability, education and skills levels, and market efficiency (Schwab, 2019). An increase in global competitiveness means greater capacity for attracting investment, enhancing productivity, and promoting economic growth.

EB (Ease of Doing Business): Operational definition: Ease of doing business refers to the simplicity and speed of conducting business and economic activities in a country. The Ease of Doing Business Index, developed by the

World Bank, includes criteria such as ease of starting a business, obtaining permits, access to electricity, property registration, and access to credit (World Bank, 2020).

EC (Economic Complexity): Operational definition: Economic complexity refers to the diversity and sophistication of products and services that a country produces and exports. The Economic Complexity Index (ECI) measures the diversity and complexity of a country's export products (Hidalgo & Hausmann, 2009). Countries with high economic complexity usually possess advanced and sophisticated production capabilities, enabling them to produce and export high value-added products, thereby contributing to sustainable long-term economic growth.

GVC (Global Value Chains): Global value chains refer to international networks in which the processes of production, distribution, and consumption of products and services are extensively divided among different countries. These networks include various stages such as design, production of raw materials, assembly, marketing, and final distribution. Participation in global value chains allows countries to access new technologies, technical knowledge, and markets, and benefit from greater specialization and higher productivity in different sectors (Gereffi & Fernandez-Stark, 2016).

IF (Institutional Factors): Operational definition: Institutional factors refer to the set of structures, laws and regulations, policies, and governmental institutions that influence a country's economic and innovative performance. These factors include aspects such as rule of law, control of corruption, government effectiveness, transparency, and accountability of government institutions (North, 1990). Institutional quality can create a favorable environment for investment and innovative activities, and strengthen public trust and international cooperation. For example, countries with strong and transparent institutions usually provide a suitable environment for research and development and attract foreign investment.

NR (Network Readiness): Operational definition: Network readiness refers to a country's ability and preparedness to use information and communication technology (ICT) to enhance competitiveness and economic development. The Network Readiness Index (NRI) assesses ICT infrastructure, internet access, the extent of digital technology usage, and the level of digitalization in the country (Dutta & Lanvin, 2019). A higher ranking in the NRI indicates that a country has appropriate infrastructure for technological development and innovation and makes good use of modern technologies.

IP (Protection of Intellectual Property Rights): Recognized as one of the key institutions for the optimal allocation of resources and encouragement of innovation. As defined by the World Bank (2005), intellectual property rights protection includes a set of laws and regulations granting individuals or companies exclusive rights to exploit innovations, inventions, trademarks, literary and artistic works, and other intellectual assets. From an economic perspective, this protection reduces the risk of investment in research and development (R&D), increases incentives for creating new ideas, and facilitates the transfer of knowledge from the private sector to society. However, economists emphasize that the balance between granting exclusive rights and public access to knowledge must be maintained to prevent prolonged monopolies and disruption of competition.

The statistics related to the variables of global value storage, institutional factors, network readiness, protection of intellectual property rights, global competitiveness, ease of doing business, and economic complexity were obtained from the World Bank website under the title *World Development Indicators*, the ease of doing business index from the Ease of Doing Business website, and the innovation index from the *Global Economy* website.

The statistical population of this research includes selected upper-middle-income countries. Due to limitations in the statistics and information for these countries, this study uses data from a selected set of upper-middle-income countries, which include: Iran, Malaysia, Kazakhstan, Turkey, Bulgaria, Romania, Russia, Montenegro, Panama, Mexico, Brazil, Colombia, and South Africa. The time frame covers the years 2015–2024.

Among the suitable econometric methods for solving or reducing the problem of endogeneity of indices and correlation between explanatory variables is model estimation using the Generalized Method of Moments (GMM). This method has been widely used in econometric research to address this problem. The prerequisite for using this method is to find appropriate instrumental variables to eliminate the endogeneity problem of the intended variables; however, it has limitations such as difficulty in finding suitable instrumental variables and the scarcity of such variables. Nevertheless, this method cannot solve the problem of correlation between explanatory variables, but it can reduce or eliminate collinearity in the model.

Applying the GMM method has advantages such as accounting for individual heterogeneity, providing more information, and eliminating biases present in cross-sectional regressions, which results in more accurate estimates with higher efficiency and less collinearity. The application of GMM is more appropriate when the number of cross-sections (N) is greater than the number of time periods (T), i.e., N > T, which is the case in this study, meaning that the number of countries is greater than the number of years (Bond, 2002; Baltagi, 2008).

In general, the GMM method has the following advantages compared to other methods:

1. **Solving the problem of endogeneity of variables:** The main advantage of GMM estimation is that none of the regression variables are correlated with the disturbance term (Greene, 2008).
2. **Eliminating time-invariant variables:** The application of this method removes many variables such as culture, ethnicity, religion, and climate, which remain constant over time and are significant factors affecting per capita income and development, and which may be correlated with other variables (Baltagi, 2008).

3. Findings and Results

In the research process using the system panel data method, it is first necessary to test for the contemporaneous correlation of residuals across cross-sections. For this purpose, the Pesaran cross-sectional independence test is applied. If the calculated test statistic is greater than the critical value in the table at the 95% confidence level (the probability value of the test statistic is less than 0.05), the null hypothesis of no correlation (independence) between cross-sections will be rejected.

Table 1. Pesaran Cross-Sectional Independence Test Results

Model	Test Statistic	Probability (P-value)
Upper-middle-income countries	1.602	0.009

If the results of the Pesaran cross-sectional independence test indicate no autocorrelation across cross-sections, it will be permissible to use the Levin, Lin, and Chu test and the Pesaran–Shin test to examine stationarity. The results of the Pesaran test are reported in Table (1). The findings for the selected countries at the 95% confidence level indicate no correlation among residuals across cross-sections, in other words, cross-sectional independence. For this reason, the Levin, Lin, and Chu (LLC) test is applied. After conducting the stationarity test, at the 95% confidence level, the null hypothesis of a unit root and non-stationarity for all variables is rejected, and it is concluded that all model variables are stationary.

Table 2. LLC Stationarity Test Results

Variable Name	Variable Abbreviation	Test Statistic	Probability Value	Test Result

Innovation	GI	-8.25	0.000	Stationary
Economic Growth	EG	-1.46	0.071	Stationary
Global Competitiveness	GC	-7.90	0.000	Stationary with trend
Ease of Doing Business	EB	-10.03	0.000	Stationary
Economic Complexity	EC	-14.85	0.000	Stationary
Global Value Chains	GVC	-20.52	0.000	Stationary
Institutional Factors	IF	-16.31	0.000	Stationary with trend
Network Readiness	NR	-36.80	0.000	Stationary with trend
Protection of Individual Property Rights	IP	-18.36	0.000	Stationary with trend

The estimation results for the period 2015–2024 using the intended approach are presented in Table (3).

Table 3. Estimation Results of the Model Using the System Panel Data Method with the GMM Approach for the Period 2015–2024

Equation	Explanatory Variables	Variable Abbreviation	Coefficient	z-statistic	p-value
Equation 1	Constant	b0	33.21	22.30	0.000
	Innovation	GI	0.05	1.69	0.092
	Global Competitiveness	GC	0.07	2.85	0.004
	Ease of Doing Business	EB	0.04	2.68	0.007
	Economic Complexity	EC	1.04	6.21	0.000
Equation 2	Constant	c0	-18.65	-5.24	0.000
	Global Value Chains	GVC	0.72	20.29	0.000
	Institutional Factors	IF	1.09	2.56	0.011
	Network Readiness	NR	0.49	4.10	0.000
	Quality of Laws Protecting Individual Property Rights	IP	1.56	2.51	0.012

As shown in Table (3), the results of estimating the first equation indicate that during the study period, at the 90% confidence level, the effect of the innovation index on economic growth in the selected countries was positive and significant. This implies that higher levels of innovation in the selected countries can lead to increased economic growth. Moreover, the results show that during the study period, the effect of the global competitiveness index on economic growth in the selected countries was positive and significant at the 95% confidence level. Based on the estimation results, it can be stated that improvement in the ease of doing business leads to the enhancement and continuity of economic growth. According to the model estimation, the effect of economic complexity and innovation on economic growth in the selected countries is positive and significant at the 95% confidence level.

The results of estimating the second equation indicate that the effect of global value chains on innovation in the selected countries is positive and significant at the 95% confidence level. Furthermore, according to the estimation results, the effect of institutional factors on innovation is positive and significant at the 95% confidence level. In other words, it appears that an increase in the network readiness index can be among the reasons for higher innovation in the selected countries through improved productivity and reduced costs. The estimation results also indicate that the index of protection of individual property rights has a positive and significant effect on innovation at the 95% confidence level. In fact, it can be said that improving the business environment in countries is an important factor for increasing investment and economic growth, and as long as the business environment does not improve, investment from firms will not be feasible.

One of the critical issues in regression estimation is the endogeneity of explanatory variables. To test for variable endogeneity, the Durbin–Wu–Hausman test and the Sargan difference test can be used. The null hypothesis (H_0)

of these tests assumes the exogeneity of the variables. At the 95% confidence level, if the obtained probability value is less than 5%, the null hypothesis (H_0) will be rejected, and the endogeneity of the variables will be confirmed.

Table 4. Endogeneity Test Results

Equation	Durbin Test Probability	Durbin Test Statistic	Wu–Hausman Test Probability	Wu–Hausman Test Statistic	Sargan Difference Test Probability	Sargan Difference Test Statistic
Equation 1	0.000	18.76	0.0000	23.54	0.001	10.67
Equation 2	0.052	3.76	0.066	3.50	0.001	10.28

Based on Table (4), as observed, the null hypothesis in both equations regarding the exogeneity of the variables is rejected; therefore, the variables in both models are endogenous.

One of the diagnostic tests for system panel data models estimated using the Generalized Method of Moments (GMM) is the Hansen J-test, which is employed to verify the validity and relevance of the instrumental variables.

Table 5. Overidentifying Restrictions Test (Hansen J-Test) Results

Equation	Probability	Test Statistic
Equation 1	0.716	0.132
Equation 2	0.146	2.11

In this test, the null hypothesis means that the selected instruments are valid and the structural model is correctly specified. Based on the research findings, at the 95% confidence level, the null hypothesis is not rejected, indicating that the presented structural model is appropriate.

4. Discussion and Conclusion

The findings of this study provide empirical evidence on the bidirectional relationship between innovation and economic growth in selected upper-middle-income countries during the period 2015–2024, using a dynamic panel data approach with the Generalized Method of Moments (GMM) framework. The results from the first equation indicate that the innovation index has a positive and significant effect on economic growth at the 90% confidence level. This outcome aligns with the predictions of endogenous growth theory, which posits that innovation is a critical driver of long-term productivity gains and economic expansion through the creation of new products, processes, and markets [1, 2]. The findings are consistent with previous empirical studies that have demonstrated a reinforcing effect of innovation on GDP growth across different economic contexts [7, 8]. Higher levels of innovation appear to enhance the efficiency of resource utilization and enable countries to move into higher value-added segments of production, thereby boosting their overall economic performance [10, 11].

The analysis also shows that the global competitiveness index exerts a positive and significant impact on economic growth at the 95% confidence level. This result is in line with the notion that competitive economies are better positioned to attract investment, integrate advanced technologies, and sustain high levels of productivity [3, 6]. Competitive markets encourage innovation by fostering rivalry among firms, which in turn drives efficiency and stimulates technological advancement [1, 13]. These results confirm the view that macroeconomic environments conducive to competition—characterized by transparent regulatory frameworks, strong institutions, and efficient market structures—are essential for leveraging innovation as a growth driver [14, 15].

The positive and significant relationship between the ease of doing business index and economic growth observed in this study reinforces the argument that a favorable business climate is fundamental to entrepreneurial activity and innovation diffusion [3, 4]. Regulatory efficiency, simplified administrative procedures, and secure property rights reduce transaction costs and uncertainty, enabling firms to allocate resources more effectively toward productive and innovative activities [5, 12]. This result also supports the contention that improvements in the business environment facilitate investment and market entry, enhancing competitive pressures and driving economic performance [8, 13].

A particularly noteworthy finding is the significant positive effect of economic complexity on economic growth. The economic complexity index captures the diversity and sophistication of a country's productive capabilities, which are closely linked to innovation potential [6, 10]. Countries with higher complexity indices are typically those that can produce a wide range of knowledge-intensive goods, reflecting deep capabilities in technology, human capital, and production networks [11, 12]. The results echo prior research indicating that economic complexity contributes to sustained growth by facilitating the diffusion of innovation across industries and enhancing resilience against external shocks [1, 2].

The second equation in the model provides additional insights into the determinants of innovation. The results show that participation in global value chains (GVCs) has a strong and significant positive effect on innovation. This finding is consistent with the literature emphasizing the role of international production networks in enabling technology transfer, knowledge spillovers, and access to advanced markets [14, 16]. By engaging in GVCs, firms and industries in participating countries are exposed to higher standards, innovative practices, and collaborative opportunities with foreign partners [1, 6]. These interactions can accelerate domestic innovation capacity by enhancing firms' absorptive capabilities and stimulating investment in R&D [17, 18].

Institutional factors also emerged as a significant determinant of innovation, confirming the central role of governance quality, regulatory stability, and effective institutions in creating an enabling environment for technological advancement [3, 21]. The positive impact of institutional quality on innovation observed here is consistent with prior research suggesting that transparent legal systems, enforcement of contracts, and protection against corruption provide the incentives necessary for firms to invest in innovation [4, 13]. Strong institutions not only safeguard property rights but also foster trust among economic actors, facilitating collaboration and long-term investment [5, 15].

The network readiness index was also found to positively and significantly affect innovation, underscoring the importance of information and communication technology (ICT) infrastructure in supporting innovative activities [14, 16]. Adequate ICT infrastructure enhances connectivity, facilitates access to knowledge resources, and supports digital transformation, which in turn accelerates the innovation process [17, 18]. This result aligns with previous findings that countries with higher levels of digital readiness are better equipped to leverage global technological trends, integrate into digital value chains, and develop competitive advantages in emerging industries [1, 6].

Finally, the positive and significant effect of intellectual property (IP) protection on innovation confirms the importance of legal frameworks that safeguard innovators' rights [3, 21]. Effective IP protection reduces the risks associated with R&D investments, increases the potential returns from innovation, and encourages the commercialization of new technologies [5, 13]. This finding corroborates the theoretical perspective that the security of intellectual property rights is essential for sustaining innovation-driven growth, as it fosters a balance between incentivizing creators and ensuring the diffusion of knowledge [1, 6].

Overall, the results from both equations highlight the mutually reinforcing relationship between innovation and economic growth. Innovation directly contributes to GDP growth by enhancing productivity and competitiveness, while growth creates the financial, institutional, and infrastructural conditions that enable further innovation [2, 10]. This virtuous cycle emphasizes the importance of integrated policy approaches that simultaneously promote innovation capacity and economic expansion [4, 11]. Furthermore, the findings underscore the multifaceted determinants of innovation, including global integration, institutional quality, ICT readiness, and intellectual property protection, all of which must be addressed to sustain innovation-led growth [6, 14].

While the study offers valuable insights into the dynamics of innovation and economic growth, it is not without limitations. The analysis is limited to a set of selected upper-middle-income countries due to data availability, which may restrict the generalizability of the findings to other income groups or regional contexts. The measurement of innovation using the number of globally registered patents, while widely adopted, may not capture all dimensions of innovative activity, particularly in sectors where innovation is less formalized or not patented. Additionally, although the GMM methodology effectively addresses endogeneity concerns, it relies heavily on the quality and validity of the selected instruments, and any shortcomings in this regard could affect the robustness of the results. The model also does not explicitly account for potential non-linearities or threshold effects in the relationship between innovation and growth, which could provide additional insights into policy prioritization.

Future studies could expand the scope of analysis by including a broader set of countries, encompassing both lower-income and high-income economies, to examine whether the observed relationships hold across different stages of development. Incorporating alternative measures of innovation, such as R&D expenditure, high-technology exports, or composite innovation indices, could provide a more comprehensive understanding of innovation dynamics. Future research could also explore sector-specific analyses to identify whether the drivers of innovation differ across industries, particularly in manufacturing versus services. Additionally, applying non-linear econometric models or threshold regression techniques could reveal whether there are critical levels of institutional quality, ICT readiness, or economic complexity beyond which the impact on innovation and growth changes significantly.

Policy-makers should prioritize strategies that enhance both innovation capacity and economic competitiveness, recognizing the interdependent nature of these processes. Investments in ICT infrastructure, education, and skills development should be coupled with reforms to strengthen institutional quality and protect intellectual property rights. Participation in global value chains should be strategically leveraged to maximize knowledge spillovers and technological upgrading, while business environment reforms should focus on reducing regulatory barriers and transaction costs. Finally, innovation policies should be designed in a holistic manner, integrating economic, institutional, and infrastructural dimensions to create a sustainable ecosystem for innovation-led growth.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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