Innovation performance and its determinants: what does it take to succeed?

Pedro Luiz Costa Cavalcante
Instituto de Pesquisa Economica Aplicada, Brasilia, Brazil

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Abstract

Purpose – This paper aims to depart from the national innovation system (NIS) arguments that countries' institutional arrangements and performance result from various complementary factors that generate innovative activities and products within economies.

Design/methodology/approach – To further explore these dimensions, the main objective of this paper is to address the determinants of global heterogeneity in the innovation outcomes of the nations. Thus, the research employs descriptive data analysis and multivariate regression models, using data from the Global Innovation Index (GII) to analyze innovation systems cross-regionally concerning institutional arrangements and performance. Since 2013, the GII, has annually measured and ranked the innovation inputs and outputs of more than a hundred countries based on a comprehensive and sophisticated approach and a multidimensional perspective.

Findings – The author found the empirical results remarkably interesting in many respects. The different indexes of innovation inputs affect the country's performance level, but not all show a statistically significant impact on innovation outputs. Institutions and infrastructure indexes do not affect the innovative performance of the economies. The main determinants of innovation performance worldwide are business sophistication, human capital & research (HC&R) and market sophistication. In short, the research presents an original contribution, mainly because it explores different views on NIS disparities worldwide, using complementary methodological strategies and based on comprehensive data on innovative inputs and outputs in the countries.

Originality/value – The findings add new evidence-based knowledge on the determinants of innovation performance in different realities, such as political, economic and administrative. These realities formulate innovation policies and implement them worldwide.

Keywords National innovation system, Heterogeneity determinants, Performance, Comparative studies, World

Paper type Research paper

Introduction

The financial crisis and the current COVID-19 pandemic have impacted the global economy and developing economies with public debt growth, slow productivity and recession. Due to these dynamic challenges to governments and firms, strengthening a nation's innovation capacity is seen as a path to generating inclusive and sustainable development. According to Kattel and Mazzucato (2018), nations worldwide have been pursuing economic growth with a strict focus on increasing the gross domestic product (GDP). Instead, this new development model must be smart (innovation-led), inclusive and sustainable, based on coherent and persistent policy mixes (instruments and funding) and capabilities of coordination (Lin and Chang, 2009).

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Three assumptions among scholars and practitioners emerge from this debate. The first is that innovation is essential for economic progress in developed and developing countries (Lin and Chang, 2009; Lundvall, 2016; Cirera and Maloney, 2017; Edler and Fagerberg, 2017). Innovation, by definition of the 2018 edition of the Oslo Manual (OECD/Eurostat, 2018), is a new or improved product or process (or a combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process). It may also contribute to solutions for urgent societal challenges (Edler, Cunningham, Gök, & Shapira, 2016; Edler and Fagerberg, 2017) and improve citizens' welfare.

The second assumption is that countries' innovation governance differs in their structure of innovation and performance, and this heterogeneity also occurs across world regions. Innovation governance levels include governments that have historically placed innovation at the center of their growth strategies, such as most member countries of the Organization for Economic Co-operation and Development (OECD). In recent decades, East Asian countries have also been competing for top innovation rankings after having experienced caught-up processes (Rodrik, 2008). In contrast, most nations worldwide struggle to build an innovative capability to move up the manufacturing, service, or agriculture value chain towards higher-value-added activities. This group includes the Latin American countries that keep facing the well-known Middle-Income Traps (MIT), in other words, the situation in which economies are stuck on the intermediate level but are not able to raise their total factor productivity to upgrade to the high-income group (Agenor *et al.*, 2012).

The third and last assumption is that a country's innovation, including its capacity, products and results, is not a consequence of a single cause but a consequence of a multidimensional phenomenon that varies in time and space. According to the literature on national innovation system (NIS) literature (Lundvall, 2016), the institutional arrangements and, therefore, the performance, result from several complementary factors that generate innovative activities and products in the economies (Cirera and Maloney, 2017).

To further explore these dimensions, the main goal of this paper is to address the determinants of a country's heterogeneity for innovation outcomes. Thus, the research employs descriptive data analysis and multivariate regression models, using data from the Global Innovation Index (GII), to cross-regionally analyze innovation systems concerning institutional arrangements and performance. The GII, since 2013, annually measures and ranks more than one hundred countries based on a comprehensive and sophisticated approach to their innovation inputs and outputs under a multidimensional analysis (Cornell University, Insead & Wipo, 2020).

The author found the empirical results remarkably interesting in many respects. The indexes of different innovation inputs affect the level of country performance. However, not all show a statistically significant impact on innovation outputs, and institutions and infrastructure indexes do not affect the innovative performance of the economies. The main determinants of innovation performance worldwide are business sophistication, human capital & research and market sophistication.

Thus, by providing original and relevant insights into the innovation and management debate, the article's findings complement recent studies that contribute to understanding how countries structure their NIS and innovate. Part of the current literature also uses the GII, focusing on innovation system typology (Cavalcante, 2022), the roles of government (Esteves and Feldmann, 2016) and efficiency and effectiveness (Bakhtiar, Ghazinoory, Aslani, & Mafi, 2021). Concurrently, others employ different data sources and methodological approaches to compare a more restricted group of countries (Choi and Zo, 2019; Kudryavtseva *et al.*, 2016; Yesilay and Halac, 2020).

Besides this introduction, this paper has three other sections. The next discusses the literature on the innovation systems' determinants and presents the study's hypotheses. The third section describes the methods, empirically analyzes the differences among countries and regions, and tests the hypothesis. Finally, the author discusses the final considerations and future research agenda.

Innovation's determinants: the NIS approach

The in-depth investigation of the factors that affect the innovation performance of countries, the heterogeneity observed between them, and the regions of the world are grounded on the literature on NIS. The NIS approach emerged during the late 1980s and early 1990s and became popular among policymakers willing to generate scientific knowledge, technology and innovation (Edler and Fagerberg, 2017). The innovation system means two complementary concepts: (1) a tool for designing innovation policy and; (2) an analytical framework for scholars to assess innovation policies and their results.

The NIS literature is openly skeptical, with government interference restricted to market failure, as innovation flourishes in an arrangement of interactions between firms and entrepreneurs with bounded rationality and institutions in constant evolution (Cirera, Frías, Hill, & Li, 2020). According to Nelson (2016), NIS is a strand of research that recognizes, on the one hand, the complexity of many market relationships, their embedment in broader social and institutional structures and the elements of cooperation and trust that often are essential if markets are to work well. On the other hand, the role of non-market institutions, like universities and public research systems, scientific and technical societies and government programs, in the innovation process of many sectors.

An "innovation system" encompasses various institutions supporting and orienting economic activity dynamics where innovation is the key driving force (Lundvall, 2010). The system comprises elements and relationships that interact in the production, diffusion and use of innovation, based within or embedded inside a nation-state. Suppose that the most fundamental resource in the modern economy is knowledge and the critical process is learning. In that case, the primary functions of the NIS are (1) to promote interactive learning, (2) to encompass individual, organizational and inter-organizational levels that should generate positive feedback and (3) to reproduce a link of innovation capabilities to economic development (Lundvall, 2016).

The NIS approach aligns with the evolutionary theory that assumes the economy constantly changes with different agents and organizational routines, which is fundamental for the system's dynamics (Nelson, 2016). Furthermore, the institutional structure and innovation processes are path-dependent, occur mainly unplanned and are gradual and cumulative (Lundvall, 2016). It is far from being a unique event like the well-known catching-up, meaning the "process in which a late-developing country reduces its income gap (as can be specified by the word 'economic catch-up") and in technological capability (equally 'technological catch-up') compared to a leading country" (Nelson *et al.*, 2011, pp. 2-3).

Orthodox economics is concerned with the institutional arrangement that affects the optimal allocation of existing resources and emphasizes how agents make choices based on given information and skills. NIS scholars are concerned with how different institutional settings affect the creation of novel resources and address how knowledge of the world and agent expertise change the economic process. Given today's "*globalizing learning economy*" (Lundvall *et al.*, 2009), if one wants to understand how a country's innovation works, one's analysis must go beyond the traditional focus on science or the core of the innovation system (businesses and the knowledge infrastructure). Such an analysis must also encompass the broader picture: institutions and organizations that nurture competence-building and institutions that shape human interaction about innovation.

This comprehensive view of the phenomenon goes beyond the focus on research and development (R&D). It includes in the innovation system other dimensions of analysis, such as the labor market, education system, financial institutions, regulatory structures and other institutions that shape economic dynamics. Figure 1 below shows the NIS framework with its institutions and three dimensions: supply, accumulation/allocation and demand.

The system elements tend to reflect the structure of the innovation capabilities and the outcomes, which various other factors, such as historical experience, language, culture and others, can also influence. As much of technology is science-based, education, research and financial systems are vital. For example, catching up countries such as South Korea and Taiwan have prioritized these systems for decades. The public sector plays a crucial role in education and R&D, while the financial sector affects how firms organize and form networks (Nelson, 2016; Cimoli, Dosi, Nelson, & Stiglitz, 2009; Lundvall, 2010). In this approach, as public policies and programs are an essential part of the engine and are inevitable (Nelson, 2016), governments must plan, design and implement innovation initiatives in a systematic and dynamic way (Cirera and Maloney, 2017).

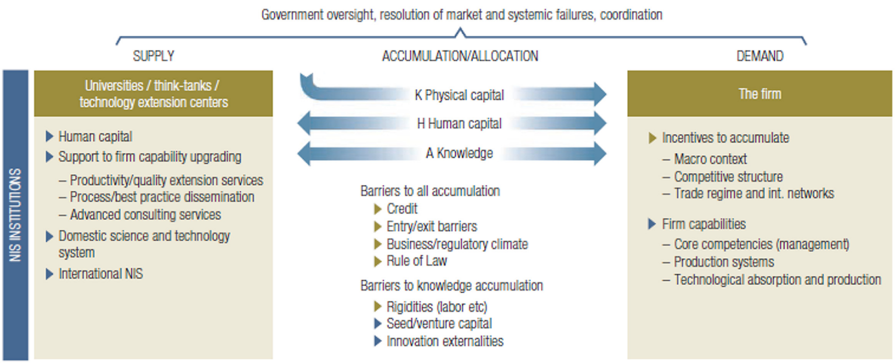
Based on the same multi-causality and dynamism assumptions, the literature argues that sustainable economic development results from structural changes based on (1) industrialization, (2) technological innovation and (3) diversification (Lin, 2012; Radosevic & Yoruk, 2018). Scholars also move beyond the narrow focus on R&D indicators towards a broader understanding of innovation and look at technological upgrading, arguing that there are several paths to achieve it.

In general, institutions and government policies and or programs matter, for better or worse, in the innovation process. As a result, the State diversifies typical responsibilities by supporting science and development, providing a business environment, setting regulations and standards, fostering interaction and cooperation between firms, and being the primary user of private sector innovations. In this sense, how are these functions formulated and implemented?

One way of looking at it is the idea of government as a gardener in which policies should identify, protect and promote interactive learning spaces (World Bank, 2010). Based on this perspective, governments must perform in a governance model that requires enabling innovation processes by using the right policy mix in different areas - education, research, trade, finance and industry, among others, to:

(1) support innovators through appropriate incentives and mechanisms,

(2) remove obstacles to innovative initiatives,



Note(s): NIS = National Innovation System

Source(s): Cirera and Maloney 2017, based on Maloney (2017)

Figure 1. The national innovation system

(3) establish responsive research structures and

(4) form a creative and receptive population through appropriate educational systems.

However, countries face these policy challenges in different strategies and conditions that may result in different stages of the NIS: mature (well-functioning) or systemic failure. The latter occurs whenever emerging innovation systems lack the building blocks to support creating, absorbing, using and disseminating helpful knowledge through interactive learning (Lundvall *et al.*, 2009). It tends to be shared in developing countries with structural issues, such as poverty and inequality, where resources are limited, managers can carry out these programs and policy measures are scarce (Cozzens and Kaplinsky, 2009; World Bank, 2010). According to Cirera and Maloney (2017), the challenge seems even harder for developing countries that face the innovation policy dilemma, which is:

> The greater magnitude of the market failures to be resolved and the multiplicity of missing complementary factors and institutions increase the complexity of innovation policy. At the same time, governments' capabilities to design, implement, and coordinate an effective policy mix to manage it are weaker. (Cirera and Maloney, 2017, p. 111).

On the contrary, there is a consensus that the quality of the innovation policy and the functioning of the governance arrangement is essential, with its organizations, governmental and outside the public sector, resources institutions, strategic goals and others. They create an accumulation of knowledge, foster the learning process, and, as a result, technological transformation and economic progress occur (World Bank, 2010; Lundvall, 2016). Furthermore, Cirera *et al.* (2020) suggest that policymakers' conception of the NIS should promote traditional institutions as well as policies to overcome innovation-related market failures and include these broader complementary factors and supporting institutions.

Indeed, there is a great variety of countries and sector-specific combinations between the types of policies. For instance, it is well-known that countries from the Organization for Economic Co-operation and Development (OECD) have an NIS with mature institutions and comprehensive, multifaceted and sophisticated policy mixes. In contrast with emerging economies, innovation policies are often embryonic and fragmented (Cirera *et al.*, 2020). Innovation policies—are usually needed to balance initiatives addressing capacity-building with mechanisms curbing inertia and rent-seeking. As Cimoli, Dosi, Nelson, and Stiglitz (2009, p. 7) put it, "the latter is indeed one of the major elements missing in the old Latin American experience of import substitution while the former is lacking under many more recent liberalization policies."

However, for analytical purposes, research should focus not on ideal types of innovation systems but on understanding how different they are in structure and performance and the correlation between these dimensions.

Countries' innovation performance and determinants

This section discusses the theoretical assumptions of the paper based on complementary empirical analyses. First, the author describes the primary source of data and the global innovation index. Next, the author shows the correlation between innovation and development, the descriptive analysis of NIS and its performance, and, finally, the multivariate regression on the innovation determinants of the economies.

The global innovation index

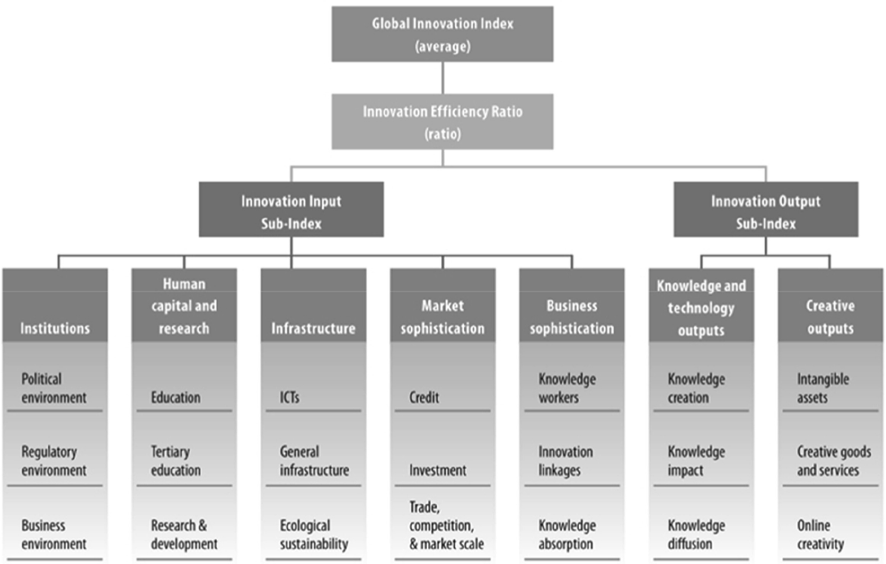
As discussed above, analyzing and comparing the performance of innovation systems requires a comprehensive and diverse approach. Therefore, this paper uses the GII, a partnership led by Cornell University, *Institut Européen d'Administration des Affaires*

(INSEAD) and the World Intellectual Property Organization (WIPO), which, since 2013, has published an annual ranking with around 130 countries and economies. The GII comprises eighty (80) simple and composite indicators from diverse sources [1] and meanings. Figure 2 shows the index, sub-indexes and leading indicators.

The GII differentiates between two dimensions or sub-indexes to capture innovation as it happens worldwide. The overall GII score is the average of the Input and Output Sub-Indexes, and varies in scores and ranks.

(1) The Input Sub-Index for Innovation assesses the critical components of a nation's political economy that are relevant to innovative activities and is divided into five pillars:

- *Institutions*: This pillar assesses the institutional framework of an economy, including its political, regulatory and, business environments;
- *Human capital and research:* This pillar assesses the level and standard of education and research activity in the country including education, higher education and research & development;
- *Infrastructure:* This pillar includes information and communication technologies (ICTs), general infrastructure and ecological sustainability indicators;
- *Market sophistication:* This *pillar assesses the* credit, investment environment, international market access, competition and market scale, which are essential for businesses and innovation;
- *Business sophistication:* This pillar assesses how companies are conducive to innovation activity involving knowledge workers, Innovation linkages and knowledge absorption.



Source(s): Global Innovation Index

Figure 2.
The global innovation index

(2) Innovation Output Sub-Index meaning the results of innovation activities above, within the economy with two pillars:

- *Knowledge and technology outputs:* covering variables that are results of inventions and innovations (knowledge creation, knowledge impact and, knowledge diffusion);
- *Creative outcomes:* The pillar has three sub-pillars that encompass the creative dimension of the NIS: intangible assets, creative goods and services and, online creativity.

In short, the GII can be used for different purposes. This index is chosen because it can comprehensively and dynamically depict innovation in an economy, including its structure and performance, beyond traditional and limited innovation measures, such as the number of research papers, the level of R&D costs, or patent production.

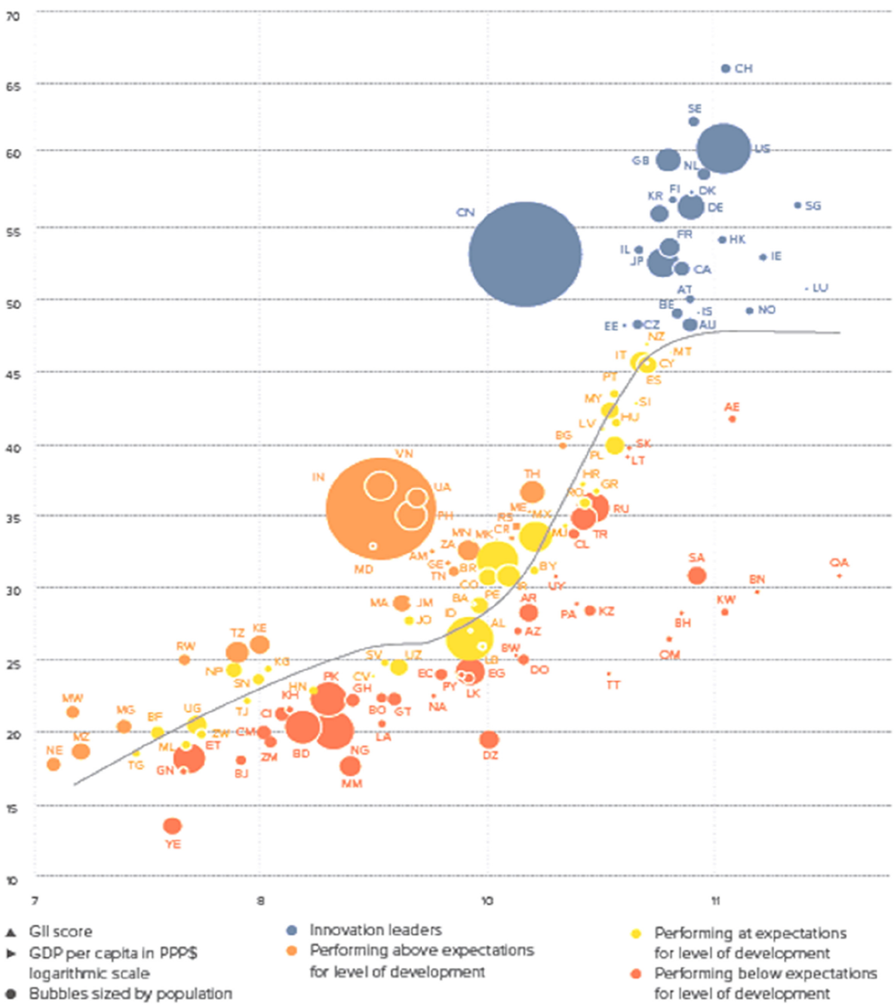
Using the GII as a primary data source, Cavalcante (2022) employed cluster analysis to propose an experimental NIS typology that would display an even more accurate description of how innovative countries are beyond income or continental cohorts. Bakhtiar *et al.* (2021), in turn, assess the efficiency and effectiveness of the performances of NISs, reinforcing how heterogeneous they are in these dimensions. Esteves and Feldmann (2016) also analyzed the correlation between economic variables and the Global Innovation Index. They found that the government's role in providing and enabling a supportive institutional environment is vital to encouraging and supporting innovation.

With fewer remarks than this paper, part of the literature has focused on various country-specific innovation systems with different approaches. Choi and Zo (2019) explore the efficiency of NIS in developing countries and show that these nations differ significantly in their innovation and operations status. Yesilay and Halac (2020), emphasizing innovation efficiency, employed data envelopment analysis (DEA) and showed that among countries in Eastern Europe and Central Asia, Kazakhstan, Turkey, Latvia and Uzbekistan are more efficient in innovation performance. Finally, Kudryavtseva *et al.* (2016) provided another comparative analysis of European countries that assessed the NIS attributes and proposed a matrix ranking method based on required spending ratios and benefits of innovation activity.

Innovation and development

The paper's first assumption is that innovation and economic progress are highly correlated in developed and developing countries (Lundvall, 2016; Cirera and Maloney, 2017; Edler and Fagerberg, 2017). A straightforward way to test this assumption is by analyzing the relations between the nations' innovation index and their Growth Development Product (GDP). Figure 3 below plots this relationship, including the overall GII and the countries' GDP per capita in natural logs and PPP (purchasing power parity in US$):

The evident and primary result is that the higher the GII of the country, the more developed the economy tends to be and the correlation (R^2) is almost 0.7 (Cornell University, INSEAD & WIPO, 2020). The relation is also apparent when we look at the trend line that indicates that among the innovation leader (blue bubbles), the level of GDP per capita has less impact on the GII. Among the rest, China is an interesting case because although it is still considered a developing economy in terms of income level, its innovation system is among the top. On the other extreme, six high-income economies from the Middle East (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates), economies with a sizeable oil-related GDP, stand out for their poor performance in the GII.



Note(s): GII (2020) and GDP per capita includes data for 2019

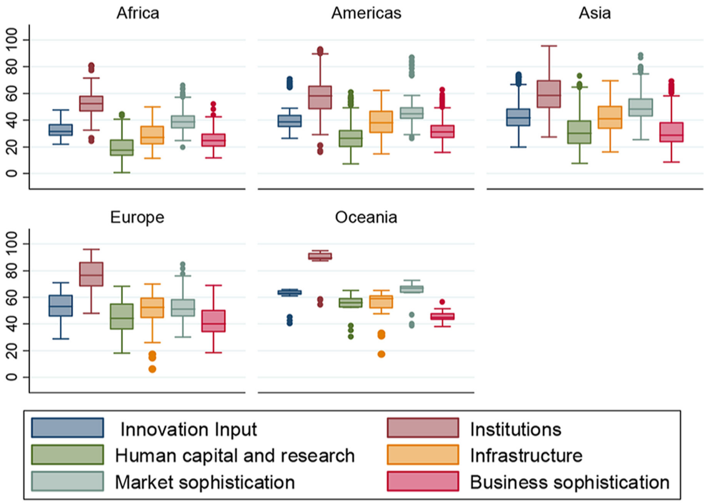
Source(s): Extracted from Cornell University, Insead & Wipo (2020)

Figure 3. Global Innovation Index and GDP per capita

Innovation structure and performance

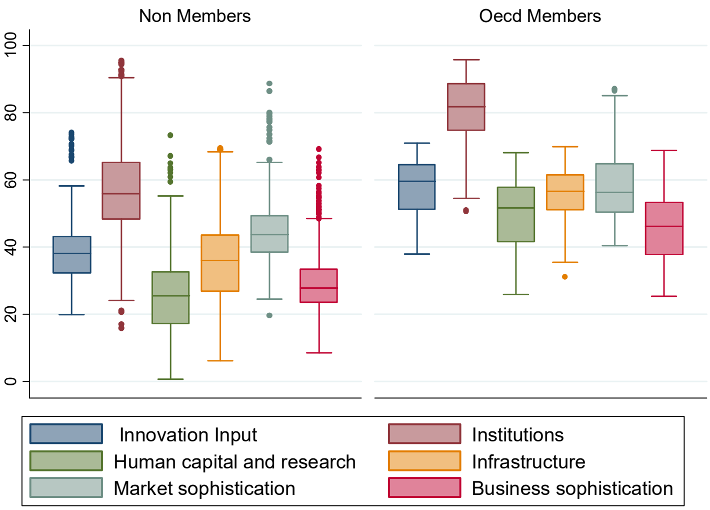
This subsection explores how the NISs are structured (GII inputs) and how they have succeeded (GII outputs) over the last eight years. The assumption to be tested is that countries' innovation governances are very different in their structure for innovation and performance. Therefore, the GII indexes differentiate by continent and divide between OECD and Non-OECD economies. Theoretically, the scores could vary from 0 to 100; however, the lowest is 7 (GII output of Togo – 2017), and the highest is 74.2 (GII input of Singapore – 2018).

Figures 4 and 5 below depict the distribution of the GII indexes of innovation inputs (II) and the pillars of institutions, human capital & research (HC&R); infrastructure; market and business sophistication. As presumed, heterogeneity is the rule either among these groups of countries or inside the continents.



Source(s): Own elaboration based on the Global Innovation Index

Figure 4.
Innovation Inputs Indexes, by continents (2013-2020)



Source(s): Own elaboration based on the Global Innovation Index

Figure 5.
Innovation structure, by non-members and OECD members (2013-2020)

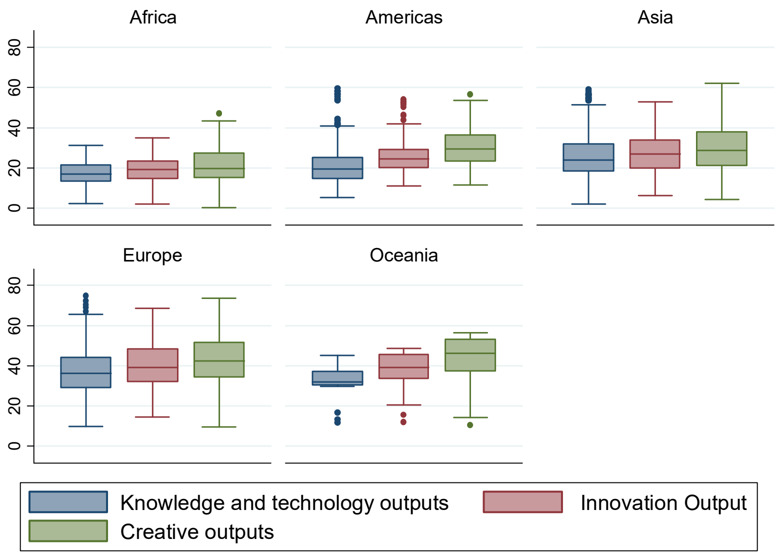
Even though all six indexes have different distributions, Oceania and Europe have the most structured national system with II scores of 60 and 53, respectively. The Asian average is also the same as the general mean (43), while Africa (33) and America (41) present indexes below it. Regarding the variation in each continent, Asia has the highest standard deviation (11.5), reflecting not only the significant number of economies but also the gap between a few innovation leaders, South Korea and Japan, for instance, and the majority of countries that are way behind in terms of innovation governance. Oceania has only two nations and presents the lowest variation (8), while the other three continents converge with a standard deviation of around 9. The five innovation structure pillars also have very different distributions; institutions and infrastructure have the highest scores among all economies. Human capital and research have the lowest average and the second-highest variation in general.

Another strategy to analyze the overview of the innovation structure globally is dividing the countries among non-members and members of the Organization for Economic Co-operation and Development (OECD). This group includes most of the high-income countries of the world. As depicted in Figure 5, the distances between these groups are much more accentuated, which exposes how rich countries prioritize the innovation agenda. In most pillars, the mean differences are around 30%, except for the (HC&R) indexes, where the average of OECD countries is almost 50% higher.

Figures 6 and 7 focus on economic performance. They use the distribution of the GII indexes of innovation output (IO) with the pillars of Knowledge and technology (KTO) and creative outputs (CO). Similarly to the inputs, the innovative results of the economies are also very diverse.

As expected, countries' performances in Europe and Oceania (mainly Australia and New Zealand) are far from the rest. The former average of the OI is 40, the latter is 37, and the general mean is around 26. The variety is evident inside each continent, with a higher standard deviation in Europe (11) and Asia (10.6). Conversely, Africa has the lowest average of innovation outputs (18), but poor performances are more homogenous than the rest, as the standard deviation is 6.

Regarding the two output pillars, Europe has the best indexes average on the KTO pillar (37.5), and Oceania is slightly better in the CO indexes (43 to 42). Africa and the Americas present the worse means in these two performance dimensions. However, the latter has more outliers that represent the outstanding results of the United States and Canada over the years. The same heterogeneity is observed in Asia since the continent's performance average aggregates innovation leaders, such as South Korea and China, and countries far behind, for example, Yemen and Myanmar, in the rank.



Source(s): Own elaboration based on the Global Innovation Index

Figure 6. Innovation performance, by continent (2013-2020)

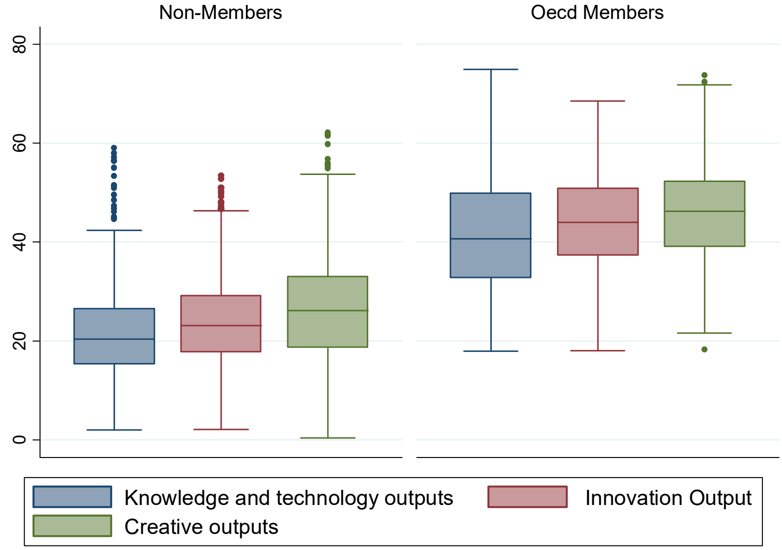


Figure 7.
Innovation performance by non-members and OECD members (2013-2020)

Source(s): Own elaboration based on the Global Innovation Index

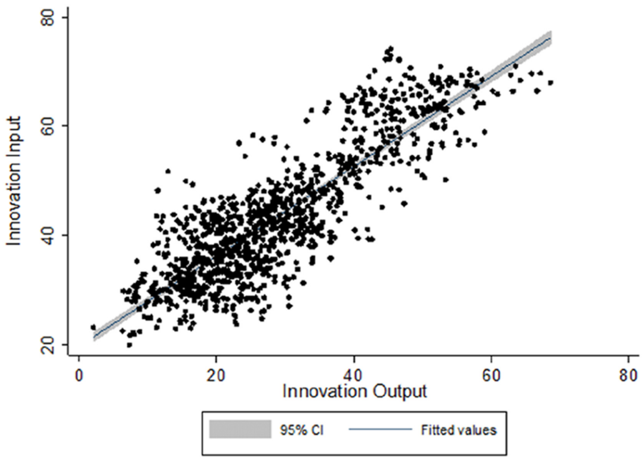
By comparing non-members and members of the OECD, the distance is even greater than previously observed in the last graph. While OECD economies have an IO average of 43.6, the rest of the countries are almost half (lower than 24), and the same pattern occurs in knowledge and technology outputs.

The heterogeneity inside these groups of economies is also evident. Since they combine a considerable number of countries, it is also expected; however, what draws attention is the fact that the standard deviations are similar, 8.7 for the non-members and 9.5 for OECD nations. Considering the variety of development of the former, it would be more reasonable to see the contrary.

Another performance pillar involves the innovation capacity of the ecosystem to be creative. The scores' distributions are also heterogeneous among the sub-pillars, for example, intangible assets, creative goods and services and online creativity. The distances from developed to developing nations in the pillar index are lower than in the previous output. Except for the dimension of online innovation, including generic and economy/country-code top-level domains, average yearly edits to Wikipedia, and mobile app creation, those OECD countries, on average, have an outstanding performance.

In sum, the descriptive results reinforce the literature findings regarding the enormous heterogeneity among the NISs worldwide (Bakhtiar *et al.* 2021; Cavalcante, 2022; Choi and Zo, 2019; Kudryavtseva *et al.*, 2016; Yesilay and Halac, 2020Yesilay & Halac, 2020). The diverse patterns are evident in both dimensions of the NIS, inputs and outputs and cross the continental frontiers.

Figure 8 shows a different focus: the correlation between the scores of the innovation inputs, how the NIS is structured in all countries, and their performance in terms of outputs. The empirical results show that the indexes are highly correlated with an R^2 of around 0.73, which can be seen in the trend line in red (fitted values). The correlation is even more significant than that between the GII and countries' development, exposed previously in Figure 3. In other words, the higher the scores of innovation inputs in the economy, the better tends to be the success in terms of innovative products and services.



Source(s): Own elaboration based on the Global Innovation Index

Figure 8. Global Innovation Input X Output indexes (2013-2020)

Innovation determinants

Empirical evidence in the initial exploratory and descriptive analysis helps to confirm the two theoretical assumptions discussed earlier: (1) a country's innovation capacity and performance are highly correlated with economic development, and (2) a nation's innovation system also considerably varies due to the outline of the theoretical grounds.

This section addresses the third assumption: innovative activities and products within economies are multidimensional phenomena affected differently by complementary factors (Lundvall, 2016; Cirera and Maloney, 2017). Therefore, this paper employs multivariate regression models with, on the left side, the dependent variables, the GII innovation output sub-index, and the knowledge and technology and creative outputs indexes. On the right side, there are all five innovation inputs indexes. The regression covers data from 2016 to 2020; as in the previous years (2013 to 2015), the dependent variable did not show statistically significant means, compromising the model's fitness. Therefore, the equation for the fixed effects model is defined as follows [2]:

$$\begin{aligned} Innovation\ Performance\,(Y)_{it} = {} & \beta(X)_1\, Institutions_{it} \\ & + \beta(X)_2\, Human\ Capital\ and\ Research_{it} \\ & + \beta(X)_3\, Infrastructure_{it} + \beta(X)_4\, Market\ Sophistication_{it} \\ & + \beta(X)_5\, Business\ Sophistication_{it} + \alpha_i + u_{it} \end{aligned}$$

Where,

(1) α_i (i = 1. . .*n*) is the unknown intercept for each entity (*n* entity-specific intercepts);

(2) Y_{it} is the dependent variable (DV) where i = entity and t = time;

(3) X_{it} represents the independent variable (IV);

(4) β_1 is the coefficient for that IV, – u_{it} is the error term.

The number of observations includes most countries worldwide; however, these are unbalanced panel data because not all countries publish their GII annually. The fixed effect models over time (year) with longitudinal data, presented in Table 1, demonstrate that the models show interesting estimates for analysis, despite their different coefficients of determination. Considering the large sample, the T and *F*-tests are valid asymptotically. Although not all variables are statistically significant, the significance of regressions is generally confirmed (Wooldridge, 2016).

Table 1 presents the estimated coefficients, standard errors in parentheses and the models' coefficients of determination (R2). To begin with, the R2 (overall) that measures how much of the variation in the dependent variable is captured by the regression in the model a indicates that input's indexes explain almost 80% of the countries' innovation performance. While in the output sub-pillars, the explanation capacity of the models is 66% and 68%, which are expressive.

Empirical results do not refute the assumption that the innovative activity of economies is a multidimensional phenomenon and is affected differently by complementary factors (Lundvall, 2016; Cirera and Maloney, 2017). However, surprisingly, some estimates of some IVs do not impact the performance indexes as expected. Only two inputs have statically significant effects in all three models. The market sophistication index, which includes credit, competition and investment environment indicators, shows that the worse the input score, the better the innovation performance, diverging from the NIS literature (Edler and Fagerberg, 2017; Nelson, 2016).

Business sophistication works the other way around, as, on average, an increase in this index tends to reflect an increase of about 0.20 in all three performance indexes. It, therefore, means that the level of knowledge workers, innovation linkages, including public, private, academic and international partnerships, and knowledge absorption appear to be critical determinants of economies' outputs and outcomes. In this case, the estimates present effects that align with the theoretical expectations (Lundvall, 2010, 2016; Cirera and Maloney, 2017).

Another result concerns the index of institutions, which encompasses political, regulatory and business environments. In either model, the estimates are statistically significant. In CO (model c), the coefficient is even negative, implying that a worse score in the institutions pillar

Inputs indexes	Innovation output (a)	Knowledge and technology outputs - KTO (b)	Creative outputs - CO (c)
Institutions	0.14	0.51	−0.08
	(0.04)	(0.04)	(0.06)
Human capital & research (HCR)	0.17***	0.07	0.27***
	(0.04)	(0.05)	(0.06)
Infrastructure	0.21***	0.24	0.40***
	(0.04)	(0.04)	(0.06)
Market sophistication	−0.12***	−0.15***	−0.10***
	(0.03)	(0.04)	(0.05)
Business sophistication	0.19***	0.20***	0.18***
	(0.03)	(0.04)	(0.05)
Constant	13.0***	19.7****	6.29***
	(3.94)	(4.53)	(6)
N	641	641	641
R^2 within	0.23	0.1	0.19
R^2 between	0.79	0.68	0.2
R^2 overall	0.78	0.66	0.07

Note(s): Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Source(s): The author's own elaboration based on the global innovation index

Table 1. Innovation performance' determinants

negatively impacts countries' innovation performance. The results put well-known normative assumptions into perspective, such as, for example, the one that argues that a democratic regime, measured by Western standards, would positively impact the innovation results of countries because information tends to flow freely, leading to a more dynamic interaction of knowledge and learning process, vital for the innovation system to prosper (Lundvall, 2010).

In this case, Gao, Zang, Roth, and Wang (2017) have already tested the effects of democracy on innovation, using the difference-in-differences method on panel data from more than one hundred countries, and concluded that there was no direct positive impact. Another explanation for this unexpected result is the complexity and fragility of the institutional index, primarily based on World Bank indicators, which are constantly criticized by experts (Andrews, 2008).

In models *a* and *b*, the coefficients of HC&R and infrastructure showed statistical significance and a positive effect on the economies' innovative results, which converges with the field of study mainstream view (Cirera *et al.*, 2020; Lacasa, Jindra, Radosevic, & Shubbak, 2019; World Bank, 2010). In both models, the estimated effects on CO are higher than on the general index of innovation outputs, as expected. However, it is striking that the human capital & research estimate in model *b* is not statistically significant on KTO. This result diverges from the literature, which supports that investments in education and research and development (R&D) are influential factors that allow innovation to succeed (Nelson, 2016; Cimoli *et al.*, 2009; Lundvall, 2010).

Final remarks

This paper discusses how countries structure the innovation system to promote prosperity in their firms and public organizations and deal with the dynamic challenges of society. In short, the research makes an original contribution, mainly because it explores different views on NIS disparities worldwide. It uses complementary methodological strategies and is based on comprehensive data on countries' innovative inputs and outputs. The findings added new evidence-based knowledge about the determinants of innovation performance in different political, economic and administrative realities in which innovation policies are formulated and implemented.

The author analyzed three theoretical assumptions with a comparative approach across countries and regions based on descriptive data analysis and multivariate regression models to address this. They then used the GII, which portrays economies that build NISs and how they succeed in this policy dimension.

The first assumption relates innovation to the level of economic progress of countries and regions, as supported by the field of study (Lundvall, 2016; Cirera and Maloney, 2017; Edler and Fagerberg, 2017). The research confirmed it by comparing the GII and the countries' GDP per capita based on the last edition of the indexes. Results demonstrate a high correlation between the two variables and also that richness may not be the only innovation determinant since six Middle East countries, economies with oil-dependent GDP, perform poorly on the index. Besides, among innovation leaders, the level of GDP per capita is not essential, and China is still an upper-middle-income country. However, the nation is among the top and has recently climbed the innovation ladder rapidly.

In the second assumption, the premise that countries' innovation governance is heterogeneous is also analyzed regarding structure and performance (Lundvall *et al.*, 2009). As expected, all index pillars have evident asymmetries among and within continents. On average, Oceania and Europe have the most advanced national systems and present the best scores of innovative productions, followed by Asia, the Americas and Africa. By analyzing the distribution of the scores between members and non-members of the OECD, the empirical results showed that the gap among them is even more highlighted. Nonetheless, the variations in almost all GII pillars are not different between the rich (OECD) and low/middle-income nations.

Finally, in the third assumption, this paper analyzed the assumption that a country's innovation success or failure is not a product of a single factor since a set of drivers may affect its performance (Lundvall, 2010; Cirera and Maloney, 2017; Cirera *et al.*, 2020). To test it, the research employed panel data regression to determine which innovation inputs affect the GII performance scores. The results confirmed the assumptions but not entirely because the institution's dimension does not seem to have a significant impact and market sophistication surprisingly showed pessimistic estimates in the models. On the contrary, infrastructure, business sophistication and human capital & research, in this order, are innovation drivers.

Drawing from the NIS literature and grounded in a comprehensive and current database, the analysis reinforces these three critical premises about how nations structure and perform their innovation capacity globally. A fundamental lesson to the ones with continuously failing systems is that innovation policy must always be on the prioritized agenda, as most of the OECD countries have done for the last decades. Lin and Chang argue that relying only on a dynamic private sector is not enough to promote economic innovation growth since it requires an intelligent policy mix, state capacity building and efforts to accumulate innovative capabilities through R&D, training and production experiences. In this sense, this paper presents relevant findings regarding the global central driver of innovation performance. Therefore, it sheds light on how heterogenous the countries are in this regard and what should be their primary focus in policy design and implementation.

Despite the contribution of this research to the field of study, some findings still require further investigation, mainly the determinants of innovation performance. Undoubtedly, the analysis is hampered by the quality of some indicators that make up the GII. For example, the 'good governance' indexes used in the institution's index are constantly criticized for not having a theoretical model to support them and focus predominantly on "statistical gymnastics," which can generate problems, such as lack of consistency, correctness and replicability in their uses (Andrews, 2008). More recently, the World Bank announced the discontinuation of Doing Business, another well-known composite index also used in the GII, due to various data irregularities in recent editions [3].

A crucial dimension for countries to increase innovation progress is little addressed in the pillars of the GII, namely, the role of a nation's global interaction (Castellacci & Natera, 2013; Lacasa *et al.*, 2019). Including information on a nation's trade openness and foreign direct investment (FDI) can improve the analytical ability to explain the innovative performance of economies.

Furthermore, the future research agenda to deal with this issue and to deepen the causal explanations for the success and failure of countries' innovation systems will be able to rely on different and complementary methods. The qualitative comparative approach (QCA) can provide more accurate comparisons and include other influential factors, such as democracy, bureaucratic capacity, economic complexity, etc. In addition, case studies are also an exciting alternative for detailed description and a better understanding of why some NISs are mature and others are not.

Notes

1. For detailed information regarding the GII conceptual framework and data sources, see https://www.globalinnovationindex.org/gii-2019-report
2. After running a Hausman test, which tests whether the unique errors (u_i) correlate with the regressors, all three models show that the fixed effects technique is more appropriate than random.
3. https://www.project-syndicate.org/bigpicture/the-undoing-of-doing-business?barrier=accesspaylog

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Corresponding author
Pedro Luiz Costa Cavalcante can be contacted at: cavalcante.pedro@gmail.com

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