Entrepreneurship, intellectual property and innovation ecosystems

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Abstract
This research aims to determine the relationship between entrepreneurship, intellectual property and innovation ecosystems at a global level. To assess the structural relationships between ecosystems, the unconditional quantile regressions using annual country data are estimated from two perspectives, namely: pooled data and data with fixed effects and time control. The Global Entrepreneurship Index (GEI), the US Chamber International IP Index (IPI) and the Global Innovation Index (GII) are used as a proxy for the entrepreneurship, intellectual property and innovation ecosystem, respectively. The results indicate that the entrepreneurship and intellectual property ecosystems has a causal relationship with the global innovation ecosystem. However, when control of individual and fixed time effects is included, the relationship between ecosystems is confirmed in just a few quantiles. The sterile results require efforts from public, private and other agents to improve the performance of ecosystems, especially to increase the generation of innovative assets. This study looks at ecosystems from a different perspective, and the results are relevant to policymakers looking to improve the ecosystems of entrepreneurship, intellectual property and innovation. The originality of this article lies in bringing together issues that are generally dealt with in theoretical and empirical literature in separate domains. The study of the relationship between ecosystems from global indexes remains a little explored field, despite the various alternative approaches already investigated.

Keywords Entrepreneurship, Intellectual property, Innovation, Innovation Input, Innovation Output, Entrepreneurship Ecosystem, Intellectual property Ecosystem, Innovation Ecosystem, Global Entrepreneurship Index (GEI), the US Chamber International IP Index (IPI), Global Innovation Index (GII), Quantile regression.

1. Introduction

Schumpeter (1934) was the theoretical precursor who pointed out the relationship between entrepreneurship and innovation, especially as these categories determine growth and economic development. He advocated that innovative processes are generated by the entrepreneur, who has a high perceptive and creative capacity. Schumpeter (1934) also explains that the entrepreneur is responsible for creative destruction, which dynamizes capitalism by introducing technological innovations, spontaneously and discontinuously changing the channels of the conventional circular flow of the economy. The performance of the entrepreneur with his innovations is seen as a force that promotes and stimulates economic development.

However, although he did not explicitly discuss intellectual property rights, Schumpeter (1934) dealt with the extraordinary profit resulting from innovations introduced into the economy, which he saw as a reward paid by consumers to innovative entrepreneurs. He characterized extraordinary profits as fleeting gains, which tend to disappear as new competitors start to copy and spread innovation in the economy.

Intellectual property rights, structured from the mid-20th century and the beginning of the 21st century by the United States and advanced industrialized countries (Baker *et al.*, 2017), have the principle of ensuring that those responsible for intellectual production (inventors and authors) have the right to obtain a reward for their innovative creations. Intellectual property reinforces, formally and legally, the possibility of generating extraordinary profit according to Schumpeter (1934) through the right to exclusive production for a certain period.

Entrepreneurship, intellectual property and innovation are categories that include the participation of various economic actors that can articulate, within an institutional environment, to undertake, produce, protect and commercialize innovative assets. The protection of intellectual property plays a fundamental role in this process, constituting the strategy adopted by companies and countries, as a mechanism for economic appropriation by the innovative entrepreneurial effort.

In the scientific field, the phenomenon of entrepreneurship, intellectual property and innovation are investigated in the light of the theory of intellectual capital. Entrepreneurship is directly linked to human capital and reflects the creative capacity and skills of individuals (Yang and Lin, 2009; Luo *et al.*, 2009; Doong *et al.*, 2011; Ramezan, 2011; Secundo *et al.*, 2018; Martin-Sardesi and Guthrie, 2018). Intellectual property and innovation are examples of relevant components of structural capital, which are associated with intangible elements of organizational culture and the ability to generate technological assets (Bukh *et al.*, 2001; Burr and Girardi, 2002; Ramezan, 2011; Orlando *et al.*, 2020).

Entrepreneurship, intellectual property and innovation are also discussed based on a holistically conception, whose main characteristic is systemic research. Moore (1996) contributes theoretically to the existence of the innovation ecosystem by identifying and encompassing all economic agents in a mutually interacting relationship network.

The concept of innovation ecosystem is adapted to support the discussion on entrepreneurship ecosystems (Ács and Szerb, 2009; Ács *et al.*, 2009; Ács and Szerb, 2012; Acs *et al.*, 2013), and ecosystem intellectual property (Pugatch *et al.*, 2012; 2014; 2015; 2016; 2017; 2018; Kaplan and Beall, 2017; Pugatch *et al.*, 2017; 2018; Pugatch and Torstensson, 2019; 2020). The applied scientific literature presents a variety of methodologies that seek to measure ecosystems through composite indicators which make it possible to combine multiple dimensions of a given quantifiable reality.

Cornell University, the European Institute of Business Administration (INSEAD) and the World Intellectual Property Organization (WIPO) devised the The Global Innovation Index (GII) in 2007, whose objective was to apply metrics to measure the different dimensions of innovation annually in many countries. In 2019 the GII was calculated for 129 nations. The methodology measures five large areas designed to monitor inputs (Institutions; Human Resources and Research; Infrastructure; Market Sophistication; Business Sophistication) that define aspects of the environment favorable to innovation within an economy, and two large areas designed to monitor outputs (Knowledge and Technology Products; Creative Products).

In 2011, the Global Entrepreneurship Network (GEN) developed The Global Entrepreneurship Index (GEI), which annually measures the entrepreneurship ecosystems of several countries. In 2019, the GEI was calculated for 137 countries. The methodology uses 14 sub-areas that support the three major areas (Entrepreneurial Attitudes, Entrepreneurial Abilities and Entrepreneurial Aspirations).

In 2012, the U.S. Chamber of Commerce's Global Innovation Policy Center (GIPC) created the U.S. Chamber International IP Index (IPI), which measures the performance of countries' intellectual property ecosystems. In 2019, the index monitored 50 countries across eight specific categories in the intellectual property environment (Patents; Copyrights; Trademarks; Trade Secrets; IP Asset Marketing; Application; Systemic Efficiency; Affiliation and Ratification of International Treaties).

Through specific statistical techniques, these surveys seek to synthesize a varied and complex set of data and information about a given reality to provide a multidisciplinary and, therefore, more comprehensive view.

The problem, however, is that the methodologies used to measure ecosystems (GEI, IPI and GII) are not evaluated from a perspective of cause and effect among their component parts, especially between ecosystems. They only synthesize a final result of the status quo of entrepreneurship, intellectual property and innovation in several countries, based on the categories of variables mapped annually.

The objective of this research is to determine the relationship between entrepreneurship, intellectual property and innovation ecosystems at a global level. To assess the structural relationships between ecosystems, this work estimates unconditional quantile regressions using a panel with annual country data. GEI, IPI and GII are used as a proxy for the entrepreneurship, intellectual property and innovation ecosystems, respectively. This study analyzes ecosystems based on global indexes, and the results are relevant for policy makers looking to improve entrepreneurship, intellectual property and innovation in countries.

2. Entrepreneurship, Intellectual Property and Innovation Ecosystems

Ács and Szerb (2009), Ács *et al.* (2009), Ács and Szerb (2012), Ács *et al.* (2013), Ács *et al.* (2014) and Szerb *et al.* (2018) define the entrepreneurship ecosystem as a complex collaborative network of systems and subsystems that interact dynamically where individuals incorporate attitudes, skills and aspirations in search of innovative ventures. However, this entrepreneurship ecosystem is restricted to observing the behavioral phenomena of entrepreneurial activity, such as attitudes, skills and aspirations, which are the driving forces of capacity and the search for the generation of innovations.

The intellectual property ecosystem functions as a network of relationships between government, business and institutional actors that interact dynamically to provide protection for the intellectual assets generated by entrepreneurs who wish to innovate.

The innovation ecosystem also consists of a relationship network in which all economic agents interact with each other (Moore, 1996). In principle, the innovation ecosystem operates with the objective of gathering the necessary inputs for innovation, combining them in order to generate and materialize new goods, processes, services, among other innovative assets.

It is essential to note that the entrepreneurship ecosystem brings together important elements for momentum, capacity and the creative inspiration of the innovation ecosystem. It is assumed that the intellectual property ecosystem also influences the entrepreneurship and innovation ecosystems, objectively interfering in the strategies and stimulating individuals and organizations have to undertake and innovate.

These three ecosystems function through strong channels of connection (Figure 1), the entrepreneurship and intellectual property ecosystem being relevant inputs for the concrete generation of technological innovations. When identifying market opportunities, they seek to develop their ideas and protect them to start their businesses, in search of economic gains from innovative activity.

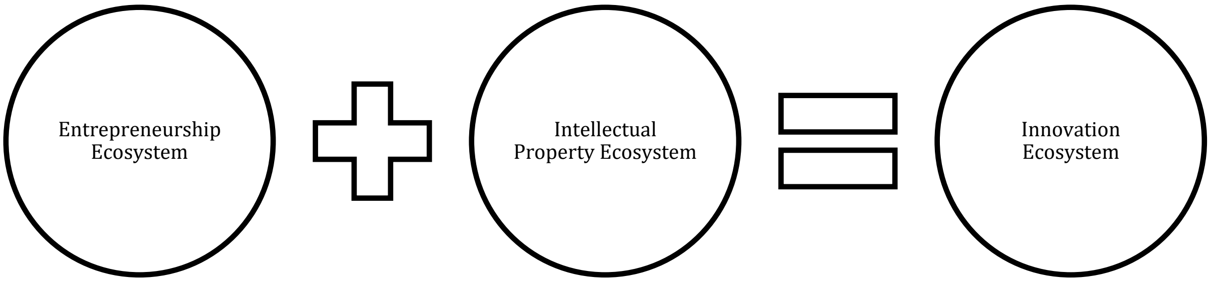

Figure 1. Concept of the relationship between entrepreneurship, intellectual property and innovation ecosystems
Source: Authors' own (2020)

The functioning of the entrepreneurship, intellectual property and innovation ecosystem is complex and regulated by a series of structural conditions (market, physical and human capital, institutions, the State, among others). The theoretical purpose of ecosystems is to operate and allocate available resources (tangible and intangible) efficiently, providing conditions for the agents involved to innovate. However, it is a process that does not generate automatic results, especially when one wants to observe the materialization of innovation in technological assets.

2.1 Global Indices

The concept developed in Figure 1, about the ecosystems of entrepreneurship, intellectual property and innovation, constitutes an important guideline that can be measured from several perspectives. As it is a relevant topic for global economic and social growth and development, several agencies have endeavored to produce a portrait of these ecosystems separately.

The GEI comprises a combination of multiple dimensions of the entrepreneurial ecosystem and classifies the data in three main areas: attitudes, skills and aspirations, as shown in Table 1. Ács *et al.* (2013) reveal that positive attitudes are understood as necessary for individuals. Competent

people choose entrepreneurship over alternative occupations, skills reflect the capacity and quality of new ventures, and aspirations reflect the potential of startups to achieve internationalization, rapid growth and high productivity.

Table 1. Composition of the GEI

Global Entrepreneurship Index	Sub-index	Pillars	Variables
	Attitudes Sub-index	Opportunity Perception	*Opportunity Recognition*
			*Freedom (Economic Freedom*Property Rights)*
		Start-up Skills	*Skill Perception*
			*Education (Tertiary Education*Quality of Education)*
		Risk Acceptance	*Risk Perception*
			Country Risk
		Networking	*Know Entrepreneurs*
			*Agglomeration (Urbanisation*Infrastructure)*

		Cultural Support	*Career Status*
			Corruption
	Abilities Sub-index	Opportunity Start-up	*Opportunity Motivation*
			*Governance (taxation*Good Governance)*
		Technology Absorption	*Technology Level*
			Technology Absorption
		Human Capital	*Educational Level*
			*Labour Market (Staff Training*Labour Freedom)*
		Competition	*Competitors*
			*Competitiveness (Market Dominance*Regulation)*
	Aspiration Sub-index	Product Innovation	*New Product*
			Tech Transfer
		Process Innovation	*New Technology*
			Science (Gerd(Average Quality of Scientific Institutions + Availability of Scientists and Engineers))*
		High Growth	*Gazelle*
			*Finance and Strategy (Venture Capital*Business Sophistication)*
		Internationalisation	*Export*
			Economic Complexity
		Risk Capital	*Informal Investment*
			Depth of Capital Market

Source: GEI (2017).

The GEI index and sub-indices are quantitative measures ranging from 0 to 100. The higher the score, the more developed the entrepreneurship ecosystem. It is reasonable to assume that, in the business environment, higher levels of attitudes and more skills qualify individuals to have more aspirations (Reis *et al.*, 2019). Therefore, it is assumed that entrepreneurial attitudes and entrepreneurial skills provide the strength for entrepreneurs to realize their aspirations for innovation.

Lagrost *et al.* (2010) set out to identify an appropriate method for evaluating intellectual property, providing useful guidance. However, the intellectual property ecosystem model proposed by Pugatch *et al.* (2018) allows countries to be evaluated from different perspectives. Table 2 provides a detailed view of the intellectual property ecosystem. The concept of an intellectual property ecosystem is evident when considering that its legal architecture may change due to the influence of economic, governmental, institutional and social actors, who interact with each other. As it evolves, the intellectual property ecosystem becomes more or less restrictive, objectively interfering in the strategies and stimulus that individuals and organizations have to undertake and innovate. The cumulative score of the IPI index ranges from a minimum of 0 to a maximum of 40. The indicators are scored using three different methods: binary, numeric and mixed.

Table 2. Composition of the IPI

	Pillar	**Variables**
IPI	Patents, Related Rights, and Limitations	Patent term of protection
		Patentability requirements
		Patentability of computer-implemented inventions
		Pharmaceutical-related patent enforcement and resolution mechanism
		Legislative criteria and active use of compulsory licensing of patented products and technologies
		Patent term restoration for pharmaceutical products
		Membership in Patent Prosecution Highways (PPHs)
		Patent opposition
	Copyrights, Related Rights, and Limitations	Copyright (and related rights) term of protection
		Legal measures that provide necessary exclusive rights that prevent infringement of copyrights and related rights (including Web hosting, streaming, and linking)
		Expeditious injunctive-style relief and disabling of infringing content online
		Availability of frameworks that promote cooperative action against online piracy
		Scope of limitations and exceptions to copyrights and related rights
		Digital rights management legislation

		Clear implementation of policies and guidelines requiring that any proprietary software used on government ICT systems should be licensed software
	Trademarks, Related Rights, and Limitations	Trademarks' term of protection (renewal periods)
		Ability of trademark owners to protect their trademarks: requisites for protection
		Legal measures that provide necessary exclusive rights to redress unauthorized uses of trademarks
		Availability of frameworks that promote action against the online sale of counterfeit goods
		Industrial design term of protection
		Legal measures that provide necessary exclusive rights to redress unauthorized use of industrial design rights
	Trade Secrets and Related Rights	Protection of trade secrets
		Regulatory data protection (RDP) term
	Commercialization of IP Assets	Barriers to market access
		Regulatory and administrative barriers to the commercialization of IP assets
		IP as an economic asset
	Enforcement	Physical counterfeiting rates
		Software piracy rates
		Civil and procedural remedies
		Pre-established damages and/or mechanisms for determining the number of damages generated by the infringement
		Criminal standards including minimum imprisonment and minimum fines
		Effective border measures
		Transparency and public reporting by customs authorities of trade-related IP infringement
	Systemic Efficiency	Coordination of IP rights enforcement efforts
		Consultation with stakeholders during IP policy formation
		Educational campaigns and awareness-raising
	Membership in and Ratification of International Treaties	WIPO Internet Treaties
		Singapore Treaty on the Law of Trademarks
		Patent Law Treaty
		At least one free trade agreement with substantive and/or specific IP provisions such as chapters on IP and separate provisions on IP rights provided it was signed after WTO/TRIPS membership

Source: Authors' own, based on GIPC (2018).

Regarding the innovation ecosystem, Saisana *et al.* (2017) state that the GII tracks innovation inputs, related to a favorable innovation environment (Institutions; Human Resources and Research; Infrastructure; Market Sophistication and Sophistication of Business) and outputs, defined as results of innovation (Technological and Knowledge Base Products; Creative Products), according to Table 3.

It is essential to highlight that innovation outputs mean the materialization of innovation and intellectual property in the economy, as they include, for example: patent deposits by residents in the national office; patent deposits filed internationally through the PCT; utility models deposited by residents in the national office; scientific and technical articles published in journals; trademarks registered by residents in the national office; industrial projects included in applications in a regional or national office; calculates the export of cultural and creative services, as a percentage of total trade; measurement of the number of national films per capita produced in a given country, among other aspects.

Table 3. Composition of the GII

GII	Sub-index	Pillars	Area
Global Innovation Index	Innovation Input	Institutions	Political environment
			Regulatory environment
			Business environment
		Human capital and research	Education
			Tertiary education
			Research & Development
		Infrastructure	ICTs
			General infrastructure
			Ecological sustainability
		Market sophistication	Credit
			Investment
			Trade, competition, & market scale
		Business sophistication	Knowledge workers
			Innovation linkages
			Knowledge absorption
	Innovation Output	Knowledge and technology outputs	Knowledge creation
			Knowledge impact
			Knowledge diffusion
		Creative outputs	Intangible assets
			Creative goods and services
			Online creativity

Source: Authors' own (2020), based in Saisana *et al*. (2017).

The GII index and sub-indices are quantitative measures ranging from 0 to 100. The higher the score, the more developed the innovation ecosystem. It is logical to assume that the higher the levels of innovation inputs, the greater the innovation products may be. These sub-indices are based on the input-output model.

Figure 2 illustrates the macro process of combining innovation efforts between the indexes and the global sub-index. We are interested in whether higher levels of robustness in the intellectual property ecosystem (IPI) combined with the performance of the entrepreneurship ecosystem (GEI) and innovation inputs (GII Inputs) result in greater innovation results. This macro process constitutes a proposal for a theoretical relational model between human capital and structural capital. Structural capital is understood as the capacity of a country to generate innovation through its human capital and the intellectual property rules that guide entrepreneurial behavior.

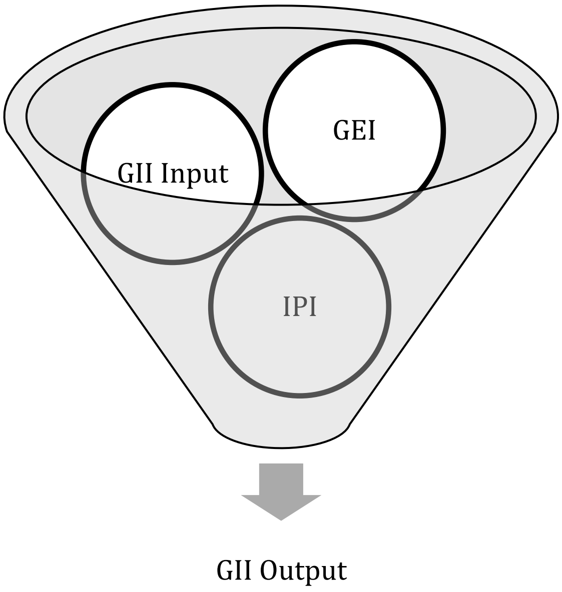

Figure 2. Macro theoretical process of combining innovation efforts and innovation output Source: Authors' own (2020)

The ecosystems of entrepreneurship, intellectual property and innovation are constituted by several economic actors that articulate, within an institutional environment, to undertake, protect, produce and commercialize innovative assets. It is expected that the creative expression of the innovative entrepreneur combined with an environment of protection of intellectual property rights will stimulate the profusion of intellectual assets.

3. Review of the Empirical Literature

The perspective of entrepreneurship, intellectual property and innovation ecosystems based on global indexes has not been developed by the empirical literature. However, a variety of studies address these ecosystems individually, or with some interrelationships.

The entrepreneurship ecosystem and the GEI were investigated by Ács and Szerb (2009), Bulut *et al.* (2013), Ghazinoory *et al.* (2014), Nataraajan and Angur (2014), Inácio Júnior *et al.* (2016), Szerb *et al.* (2016), Jovanovic *et al.* (2017), Cătălin *et al.* (2017), Szerb (2017), Atiase *et al.* (2018), Szerb *et al.* (2018), Reis *et al.* (2019) and Inacio Junior *et al.* (2020).

Other studies have assessed the role of intellectual property in the entrepreneurship ecosystem, namely: Dan and Chunyan (2006), Acs *et al.* (2009), Gu (2009), Fini *et al.* (2010), Yong and Sheng (2014) and Nogueira *et al.* (2019).

The empirical literature investigating the innovation ecosystem and GII is discussed by SaiSana (2011), Dutta *et al.* (2012), Hollanders (2013), Xiangjiang *et al.* (2013), Al-Sudairi and Bakry (2014), Dutta *et al.* (2015), Crespo and Crespo (2016), Carpita and Ciavolino (2017), Lybbert *et al.* (2017), Aubert (2018) and Salinas-Ávila *et al.* (2020).

The studies dealing with the relationship between intellectual property and innovation are represented by Dan and Chunyan (2006), Kumar and Ellingson (2007), Zhou and Hu (2007), Gu (2009) Li *et al.* (2010), Ståhle *et al.* (2011), Sweet and Eterovic (2015), Elahi *et al.* (2016), Rojas (2016), Dixit *et al.* (2018), Brandl *et al.* (2019).

There is also a set of studies that set out to investigate entrepreneurship, intellectual property and innovation in a creative way, opening up new domains at the frontier of knowledge, such as Borin and Donato (2015), Kashyap and Agrawal (2019), Alvino *et al.* (2020), Crupi *et al.* (2020), Usai *et al.* (2020) and Huang *et al.* (2020).

Empirical literature reveals some interesting perspectives. However, there was a scarcity of studies that address the possible connections between entrepreneurship, intellectual property and innovation ecosystems through global indexes. Therefore, we test three hypotheses:

H1. Entrepreneurship and intellectual property ecosystems positively affect the innovation ecosystem.

H2. Entrepreneurship, intellectual property and innovation input ecosystems positively affect the production of innovation in the innovation ecosystem.

H3. Entrepreneurship and intellectual property ecosystems positively affect the production of innovation in the innovation ecosystem.

4. Methodological Procedures

This is a quantitative study based on documentary research. Information about the sample design and the empirical estimation strategy is provided in the following subsections.

4.1 Sample design

The sample data for GEI, IPI and GII were obtained from the annual reports of GEDI, GIPC and GII between 2014 and 2019, according to the availability of data for each country, as shown in Table 4. It is relevant to highlight that the reports published annually by the GEI and the GII are always based on country data for the past two years. The published IPI report is always based on data from the country for the previous year. Thus, for the purposes of organization and estimation, data from the GEI, IPI and GII index and sub-index reports were allocated in the correct years.

Table 4. Number of countries mapped by the indexes (GEI, GII, IPI)

Index[1]	2014	2015	2016	2017	2018	2019
GEI	120	130	132	137	137	137
GII	143	141	128	127	126	129
IPI	25	30	38	45	50	50

Source: Authors'own (2020). **Notes:** 1- For more information on the methodology, consult the annual reports. To ensure better comparability and stability between the indices, we opted for the data available from 2014.

Given the changes and discontinuities in the coverage of the indices, the investigation was conducted using all the data available between 2014 and 2019 (time series and cross-country data). It is an unbalanced panel.

The non-homogeneous number of countries mapped annually by the indexes requires specific methodological treatment. In addition to the sub-indices and indices used, a control variable related to economic activity from the World Bank was introduced, as shown in Table 5.

Table 5. Variables used

Fonte	Variáveis	Sigla
GEDI/GEI	Attitudes; Abilities; Aspirations	GEI
GII	Innovation Inputs	INPUT
GII	Innovation Products	OUTPUT
GII	Innovation Inputs and Products	GII
GIPC/IPI	U.S. Chamber International IP Index	IPI
World Bank	Gross Domestic Product per capita based on Purchasing Power Parity (international dollars of GDP - base 2011)	GDP

Source: Authors' own (2020).

4.2 Empirical Model

The indices cover several countries with varied dynamics and economic performance, as well as specific social, political and cultural characteristics. Therefore, it is essential to consider the high heterogeneity in the structural relationship. We propose the estimation of quantile regression models in a panel with pooled data and fixed effects.

Quantile regression has been used to analyze the behavior of a response variable throughout its distribution. The effect on the expected or average value can hide important characteristics of the behavior of the response variable. In addition to controlling unobserved and time-invariant heterogeneity, quantile panel regression with fixed effects can assess the effect of a specific covariate on different quantiles of the response variable, which makes the inference more informative and robust.

Koenker and Bassett (1978) were pioneers in quantile regression. Koenker (2004), Firpo *et al.* (2009; 2018), Bache *et al.* (2013), Powell (2017) and Rios-Avila (2019) also proposed estimators for longitudinal data.

In our investigation, we used an unconditional quantile panel regression based on the Recent Influence Function (RIF) proposed by Firpo *et al.* (2009) and Rios-Avila (2019). This method has the advantage of separating the composition and structure effects of the variable of interest for any statistic. The structure effect indicates how the F (Y | X) distribution changes over time. The calculation of the probabilities for each group obtained in the propensity score is re-weighted and used to estimate the RIF regression. This regression replaces the dependent variable with the estimated RIF value.

Firpo et al. (2009) and Rios-Avila (2019) propose the model with the following general structure:

$$RIF\left(y_i; v(F_y)\right) = X_i'\beta + \varepsilon_i. \tag{1}$$

Firpo *et al.* (2009) and Rios-Avila (2019) use this strategy to estimate unconditional partial effects on distribution statistics v (for example, the quantiles of the response variable) from marginal changes in the distribution of covariates. The linear regression RIF (i.e. RIF-OLS) uses the estimated value $RIF(y_i; v(F_y))$ for each observation y_i as a second step response variable. The unconditional partial effects can be estimated by first calculating the unconditional expectation of equation (1) (Rios-Avila, 2019):

$$E\left[RIF\left(y_i; v(F_y)\right)\right] = v\left(F_y\right) = E(X_i'\beta) + E(\varepsilon_i) = \bar{X}'\beta, \tag{2}$$

assuming $E(\varepsilon_i) = 0$. The unconditional partial effect for the independent variable x_k is given by:

$$\frac{\partial v(F_y)}{\partial \bar{x}_k} = \beta_k \tag{3}$$

The coefficient β_k is the expected change in distributive statistics v (for example, a specified quantile) given by a unit change in the unconditional average of x_k. In line with the hypotheses of this study (H1; H2; H3), we estimate three models:

$$GII_{it} = \beta_0 + \beta_1(\tau)\, IPI_{it-1} + \beta_2(\tau)\, GEI_{it-1} + \beta_3(\tau)\, GDP_{it-1} + C_i + \delta_t + \varepsilon_{it}, \tag{4}$$

$$OUTPUT_{it} = \beta_0 + \beta_1(\tau)\, IPI_{it-1} + \beta_2(\tau)\, GEI_{it-1} + \beta_3(\tau)\, INPUT_{it-1} + \beta_4(\tau)\, GDP_{it-1} + C_i + \delta_t + \varepsilon_{it}, \tag{5}$$

$$OUTPUT_{it} = \beta_0 + \beta_1(\tau)\, IPI_{it-1} + \beta_2(\tau)\, GEI_{it-1} + \beta_3(\tau)\, GDP_{it-1} + C_i + \delta_t + \varepsilon_{it}, \tag{6}$$

where i is the index of countries and t is the index of years. C_i is a term that captures specific unobserved and time-varying effects in each country. δ_t is a term that captures fixed time effects common to all countries. The estimator proposed by Rios-Avila (2019) allows for unbalanced panels and is implemented through the "RIFHDREG" package in STATA.

Equation (4) is an attempt to investigate the relationship between ecosystems through the aggregated indices, shown in Figure 1. In equation (5) the GII is decomposed into its sub-indices, with the variable innovation products becoming the variable strategic response that synthesizes the results of the generation of technological assets. The innovation input is incorporated as another important explanatory variable of the model, according to the macro process described in Figure 2. The rationality in the functional formula of equation (5) allows to objectively evaluate if there is a relationship between ecosystems. In equation (6) we remove the variable of innovation inputs as a way to investigate whether the ecosystems of intellectual property and entrepreneurship are sufficiently capable of affecting the profusion of innovation results in the countries, inhibiting possible disturbances in the human capital captured by the GEI and the INPUT.

The three models (4, 5 and 6) were estimated in pooling and with control of fixed effects of countries and time. We estimate the models using log variables (coefficients are elasticities). We believe that changes in intellectual property legislation in a given year do not instantly affect the innovation ecosystem or innovation results in the same year. Therefore, we expect variations in the intellectual property ecosystem to affect the production of innovation with a delay. We also assume that the contemporary model may be endogenous. The entry of the innovation can be determined simultaneously by the exit of the innovation in the same time window, as the process innovation. To overcome this problem, we delay all explanatory variables by one year.

To estimate the quantile regression with stacked data, we removed C_i and δ_t from equation (4, 5 and 6). The modeling that groups the stacked data is useful because it presents the relationship between the explanatory variables and the dependent variable in general. The limitation of this type of estimate is that the fixed and constant, time-invaryng effects are possibly incorporated into the indiosyncratic error, which may be correlated with the explanatory variables, which can generate biased results. In this sense, the fixed-effect and time model is the most appropriate because it controls the individual characteristics of countries.

5. Results

5.1 Descriptive Statistics

The theme of entrepreneurship, innovation and intellectual property ecosystems is strategic for the development of countries, and therefore it is relevant to investigate their connections. Figure 3 shows the geographical spatial location of the 47 countries in the sample. Highlighted in green, the 47 countries are distributed on all continents, which amplifies the scope of the research and the global reach of its results.

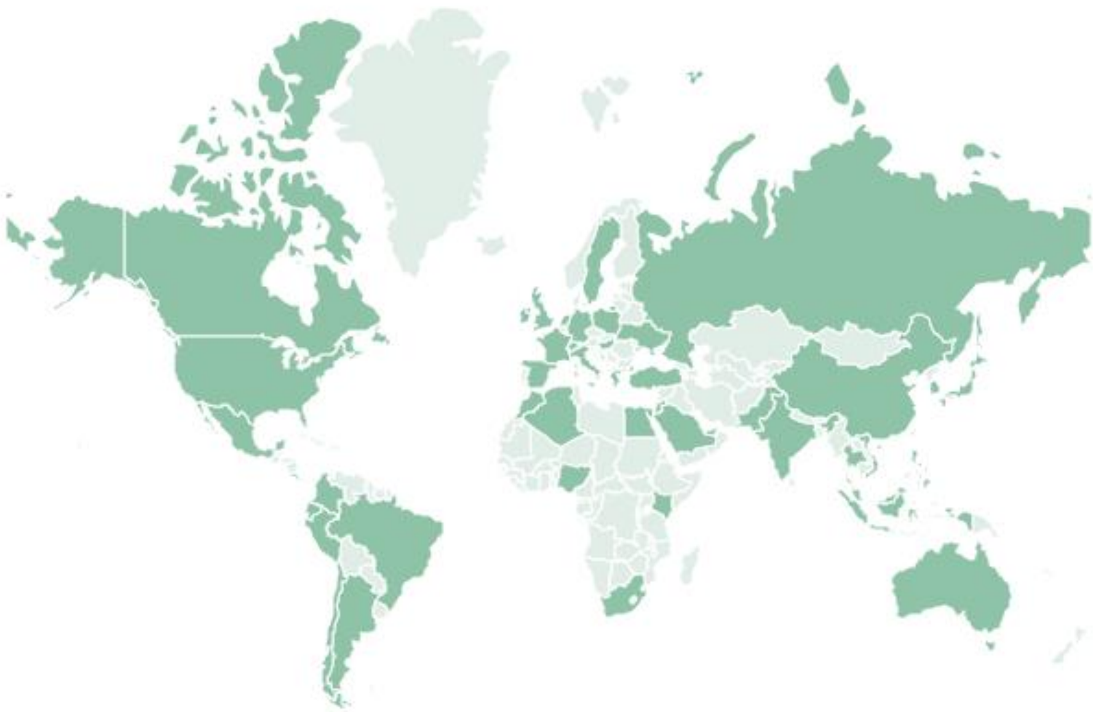

Figure 3. Spatial distribution of the sample countries
Source: Authors' own (2020)

Table 6 lists the countries in the sample according to the United Nations classification. It is important to highlight the predominance of European and Asian countries in the sample.

Table 6. Spatial distribution of sample countries

Regions	Countries	Number of Countries
Europe - EUR	France; Germany; Hungary; Ireland; Italy; Netherlands; Poland; Russian Federation; Spain; Sweden; Switzerland; Ukraine; United Kingdom.	13
North America - NAC	Canada; United States of America.	2
Latin America and the Caribbean - LCN	Argentina; Brazil; Chile; Colombia; Costa Rica; Ecuador; Mexico; Peru.	8
Central and Southern Asia - CSA	India; Pakistan.	2
Southeast Asia, East Asia, and Oceania - SEAO	Australia; Brunei Darussalam; China; Indonesia; Japan; Korea, Republic of; Malaysia; Philippines; Singapore; Thailand; Vietnam.	11
Northern Africa and Western Asia - NAWA	Algeria; Egypt; Israel; Jordan; Morocco; Saudi Arabia; Turkey; United Arab Emirates.	8
Sub-Saharan Africa - SSF	Kenya; Nigeria; South Africa.	3
Total		**47**

Source: Authors' own (2020)

In Table 7, the means of the variables used (IPI; GEI; GII; INPUT; OUTPUT; GDP) were higher than the medians, which suggests that more than half of the countries are below the average value. The high standard deviation indicates that the sample is quite heterogeneous, as expected. This evidence is confirmed by the minimum and maximum values obtained for all variables, especially the economic performance per capita (GDP) variable. The countries in the sample therefore vary greatly in the characteristics of their entrepreneurship, intellectual property and innovation ecosystems.

Table 7. Descriptive statistics (2013 to 2017)

	IPI	GEI	GII	INPUT	OUTPUT	GDP
Mean	18.16	44.32	43.10	51.28	34.92	28,164.17
Median	15.08	38.50	38.80	48.30	33.30	23,664.43
Standard Deviation	8.34	20.20	11.82	12.11	12.53	19,632.45
Minimum	6.42	13.00	21.90	26.30	12.95	2,891.49
Maximum	37.98	86.80	68.40	74.23	67.13	87,760.37
Observations	188	183	181	181	181	181

Source: Authors (2020)

Figure 4 shows the dispersion between the variable GII and each of the covariates, and OUTPUT and each of the covariates. With the exception of the GDP variable, it can be seen that the covariates are associated in an apparently linear way both for the global innovation index and for the innovation product, over time.

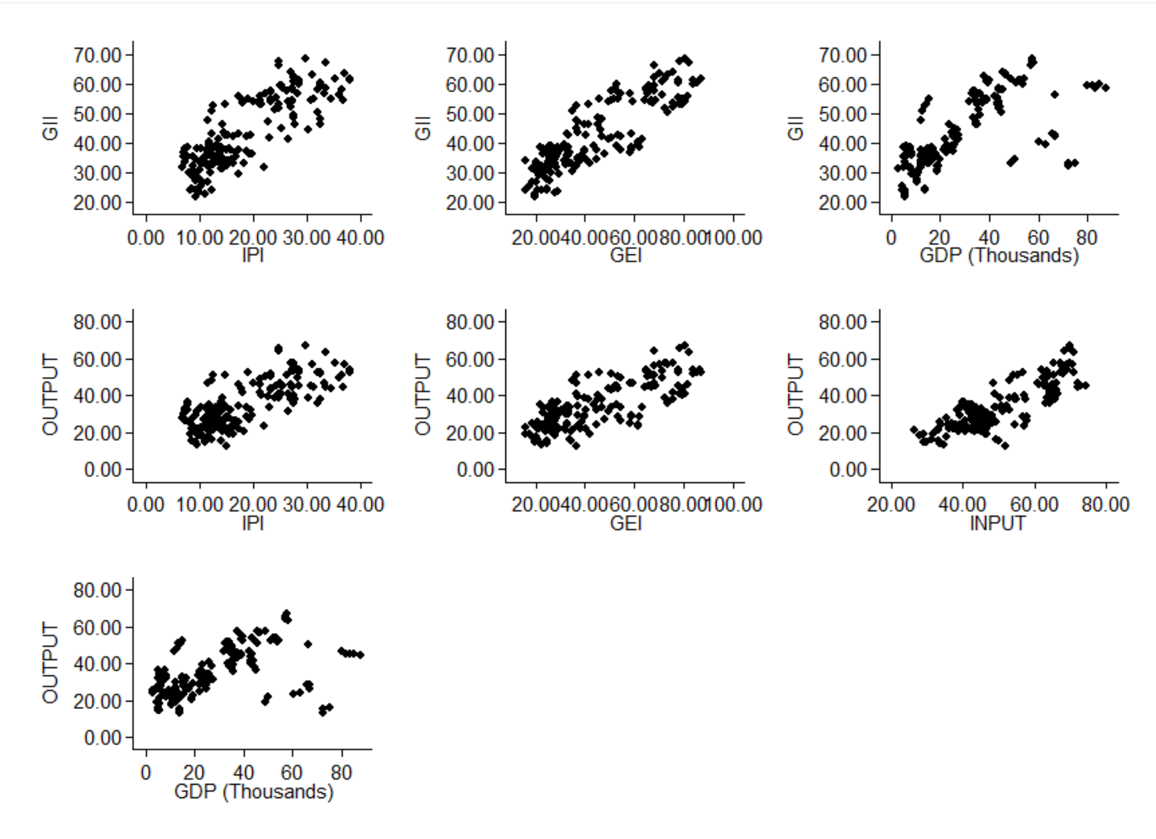

Figure 4. Dispersion of variables in the period (2013 to 2017)
Source: Authors' own (2019).

Figure 5 shows the countries' average annual performance between 2013 and 2017. The IPI index, which ranges from 0 to 40, jumped from an average of 15.32 in 2013 to 21.92 in 2017, revealing the strengthening of the global intellectual property ecosystem. Innovation inputs and GDP per capita also showed an increasing average performance between 2013 and 2017.

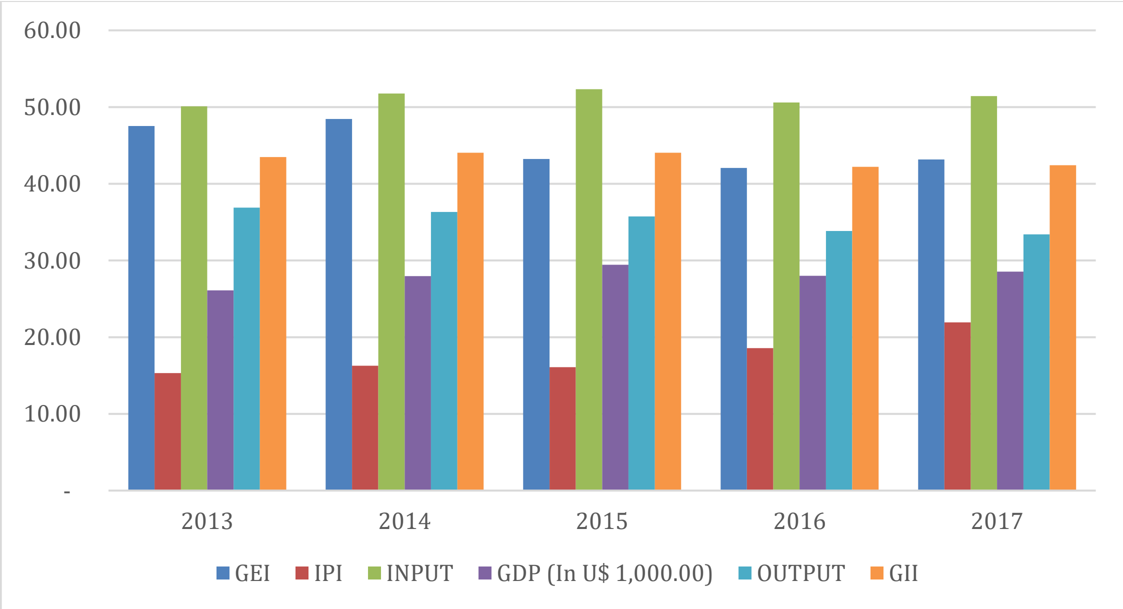

Figure 5. Annual average results (2013 to 2017)
Source: Authors' own (2020)

However, the variables GEI, OUTPUT and GII showed an average decline when comparing the year 2017 with 2013. This demonstrates that the average results of the entrepreneurship and global innovation ecosystems were low in the period. In Appendix A, we provide the geometric growth rate of the variables in this study (IPI, GEI, GII, INPUT, GDP and OUTPUT) for all the countries in the sample. We can see that half of the countries recorded a decline in the entrepreneurship ecosystem, while the majority experienced a strengthening of IP rules and a growth in innovation efforts. In addition, most countries have seen a drop in innovation production (Appendix A).

Even countries located in higher quantiles, considered highly innovative, showed a reduction in the production of innovation. Few countries achieved a positive growth rate in innovation production in the period. We argue that the highly innovative countries that lead with high scores have failed to substantially increase their production of innovation, with a few exceptions.

Table 8 contains the sample quantiles (10% to 90%). It shows that the sample composition is substantially heterogeneous. The important thing, however, is that the quantiles generated monotonically stratify the countries present in the sample. As a result, countries with the best performance in their entrepreneurship, intellectual property and innovation ecosystems occupy the highest quantile positions.

Table 8. Sample quantiles (2013 to 2017)

QUANTILE	IPI	GEI	GII	INPUT	OUTPUT	GDP
10%	8.86	21.36	29.80	36.10	20.80	6,516.17
20%	10.90	25.52	32.93	41.00	23.30	10,748.29
30%	12.30	28.16	35.34	43.12	26.35	13,534.85
40%	13.70	33.40	37.42	45.26	29.10	17,149.78
50%	15.07	38.50	38.80	48.30	33.30	23,664.43
60%	18.36	48.22	44.51	54.20	36.59	33,220.45

70%	23.31	58.18	53.06	62.60	43.00	37,575.81
80%	27.14	66.24	55.20	64.80	46.60	43,672.13
90%	30.90	74.98	59.81	67.81	52.75	54,470.80

Source: Authors' own (2019).

5.2 Regression results

The results of the estimates for all the models are available in Appendix B. We chose to present and discuss the results of the estimates through Figures. This has the advantage of showing the effect of covariables on the broader quantile distribution of the response variable with greater power information, with significance levels of 10%. Figure 6 shows the results of the quantile regression for model (4) with a focus on the ceteris paribus effect of GEI and IPI.

The results stacked in cross-section indicate that the effect of the entrepreneurship ecosystem is positive and significant on the innovation ecosystem throughout the distribution of the response, with the exception of quantiles above 70% and below 90%. The intellectual property ecosystem, on the other hand, has a significant and positive effect on the innovation ecosystem on the right tail of the distribution, more specifically above the 40% quantile.

It is also possible to observe that between the 60% and 70% quantiles, the magnitude of the IPI coefficient reaches its maximum value, starting to decline significantly to assume the inverted "U" shape. The results confirm the hypothesis (H1) that the entrepreneurship and intellectual property ecosystems positively affects the global innovation ecosystem, but in a heterogeneous way throughout the GII distribution.

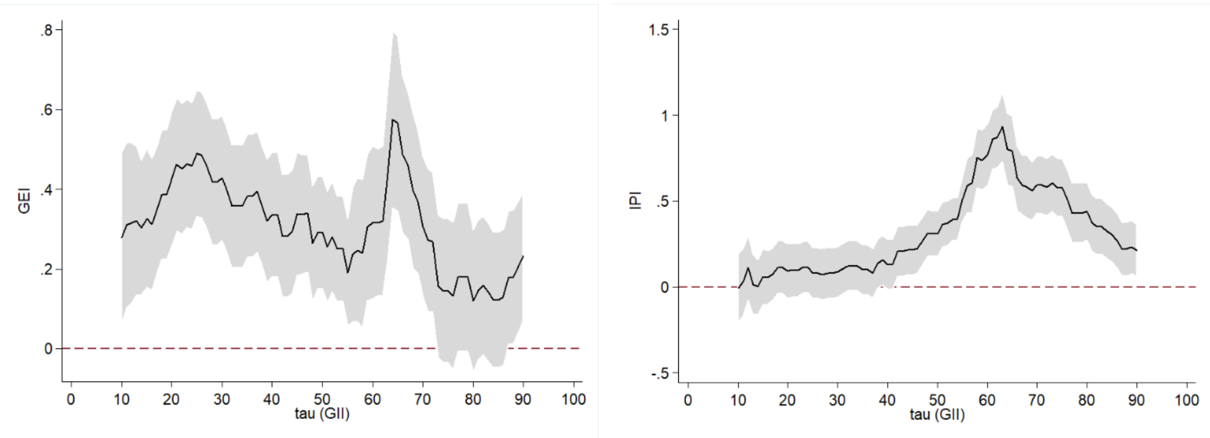

Figure 6. Effect of GEI and IPI on GII (pooled data)

Source: Authors' own (2020)

Figure 7 illustrates the results of quantile regression by controlling for individual fixed and time effects. We now observe that the elasticity of the entrepreneurship and intellectual property ecosystem is not significant. Therefore, the hypothesis (H1) is not confirmed.

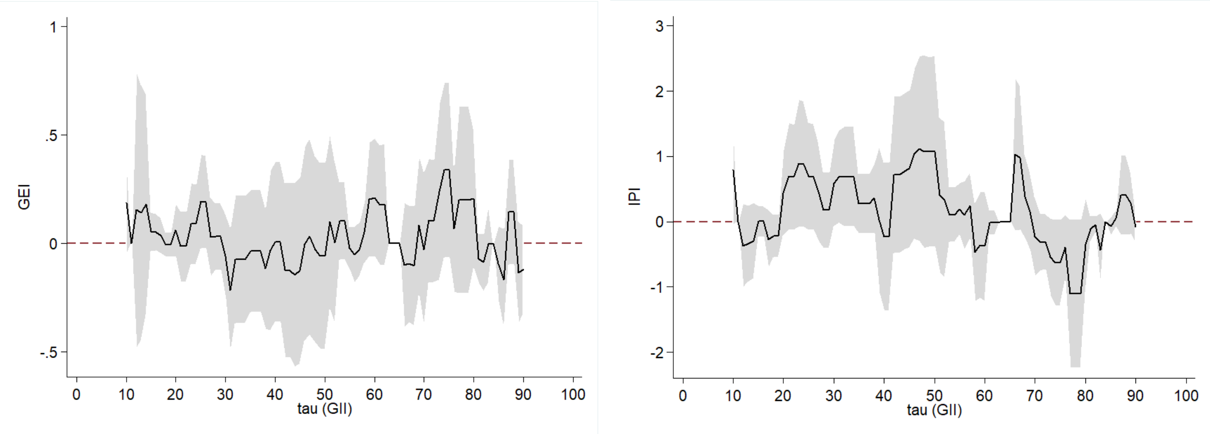

Figure 7. Effect of GEI and IPI on GII (controlling for time and country fixed effects)
Source: Authors' own (2019).

Figure 8 presents the results of the quantile regression with stacked data for the model (5), focusing on the three covariates of interest (GEI, INPUT and IPI). The results indicate that the effect of the entrepreneurship ecosystem is positive and significant on the production of innovation between the quantiles above 20% and below 30%, above 30% up to 40%, above 60%, and above 80 % up to the 90% quantile. The pattern of elasticity of the GEI is evidence that the effect of the entrepreneurship ecosystem is quite similar between the OUTPUT quantiles, that is, the relationship between OUTPUT and GEI is apparently linear.

Innovation inputs significantly and positively affect the generation of innovations in most quantiles. The intellectual property ecosystem has a significant and positive effect on the global production of innovations in the upper tail of the quantile distribution, with the exception of the 80% quantile. In summary, both innovation inputs and the intellectual property ecosystem exhibit a non-linear effect on innovation production. As we move through the quantiles, the marginal effect of covariates changes significantly. In the case of OUTPUT x INPUT the effect of INPUT decreases as it approaches the right tail, until it becomes insignificant. In the case of OUTPUT x IPI the effect of the IPI increases until it stabilizes at around 0.4 in elasticity.

The higher the level of innovation production, the greater the likelihood that the intellectual property and entrepreneurship ecosystem will impact the generation of new innovative goods, processes and services. This confirms the hypothesis (H2) and is relatively in line with the findings of Sweet and Eterovic (2015), Elahi *et al.* (2016), Brandl *et al.* (2019) and Orlando *et al.* (2020).

Figure 9 illustrates the effect of the marginal variations of GEI, INPUT and IPI on the unconditional distribution of the response, controlling the time and the individual fixed effects. We see that the effect of the entrepreneurship ecosystem is significant and positive above the 50% quantile, below and in the 60% quantile. The unconditional partial effect of innovation inputs is significant and positive in the quantiles 50% and 60%.

The intellectual property ecosystem, on the other hand, generates a significant and positive effect above the 10% quantile up to 20%. This result confirms with constraint the hypothesis (H2) that the entrepreneurship and intellectual property ecosystem positively affects the production of innovation in the countries' innovation ecosystem. The significant effect identified indicates the importance of the intellectual property ecosystem for the expansion of innovation output.

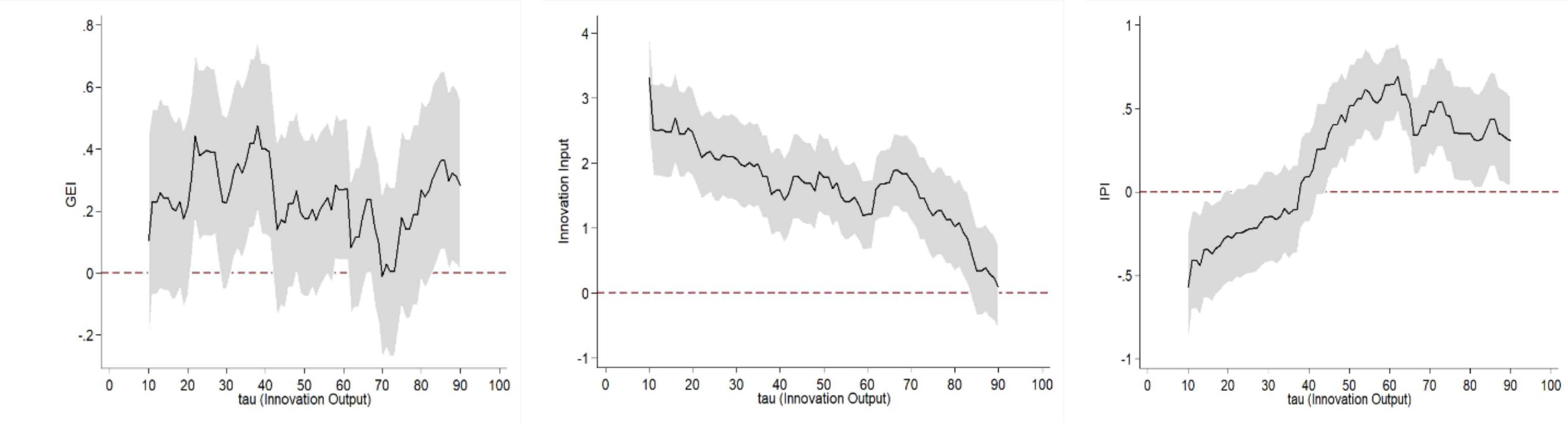

Figure 8. Effect of GEI, INPUT and IPI on OUTPUT (pooled data)

Source: Authors' own (2019).

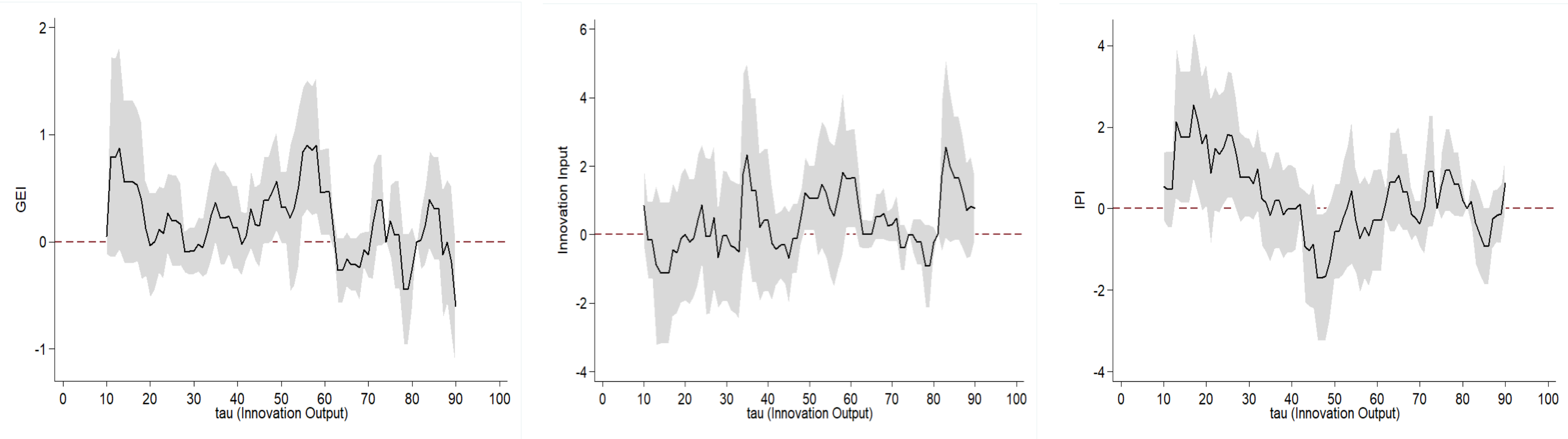

Figure 9. Effect of GEI, INPUT and IPI on OUTPUT (controlling for time and country fixed effects)

Source: Authors' own (2019).

Figure 10 shows the results of the quantile regression for the model (6). The results indicate that the effect of the entrepreneurship ecosystem is positive and significant, but decreasing, over the distribution of innovation production. This evidence is supported by Inacio Junior *et al.* (2020), who argue that innovation-oriented economies with lower positions in the GEI classification tend to have higher productivity rates when compared to economies with higher positions in the GEI classification. The intellectual property ecosystem, on the other hand, has a significant and positive effect on the global production of innovations in the upper tail of the inverted U-shaped quantile distribution. In summary, the hypothesis (H3) is confirmed in the pooling specification.

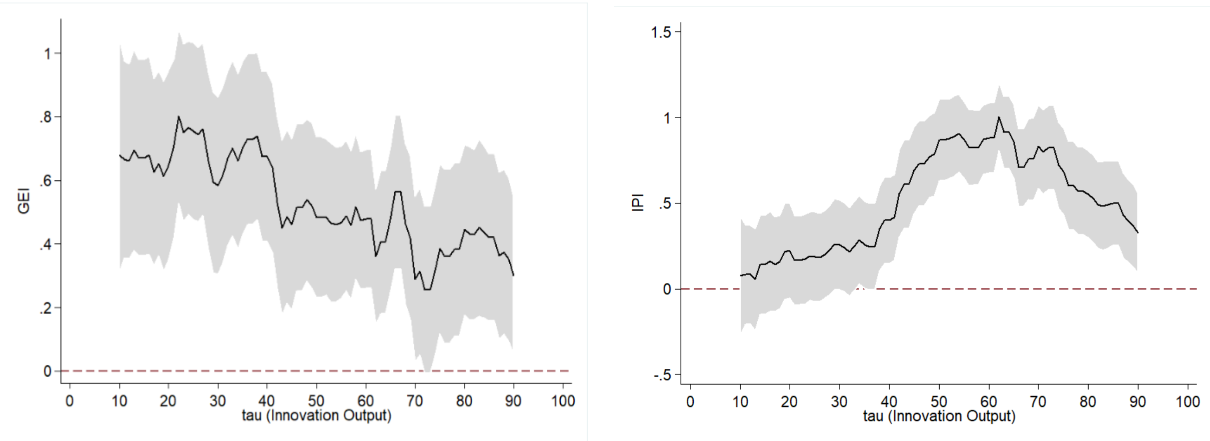

Figure 10. Effect of GEI, and IPI on OUTPUT (pooled data)
Source: Authors' own (2019).

Figure 11 details the results of the quantile regression by controlling the time and fixed effects of countries in the model (6). There is an unconditional partial effect of the significant and positive entrepreneurship ecosystem above the 50% quantile, below and in the 60% quantile. The intellectual property ecosystem generate a significant and positive effect above the 10% quantile to 20%, and below the 30% quantile. Visually, Figure 11 is similar to Figure 9, constituting an important test of robustness by discarding the variable of innovation inputs in the model (6).

In summary, changes in the entrepreneurship and intellectual property ecosystem impact the production of innovation with important restrictions, partially confirming the hypothesis (H3) in a panel configuration. The restrictions, that is, the non-significant results are in line with the discussions of Zhou and Hu (2007), Dosi and Stiglitz (2014), Baker et al. (2017), Peng et al. (2017) and Sweet and Eterovic (2015).

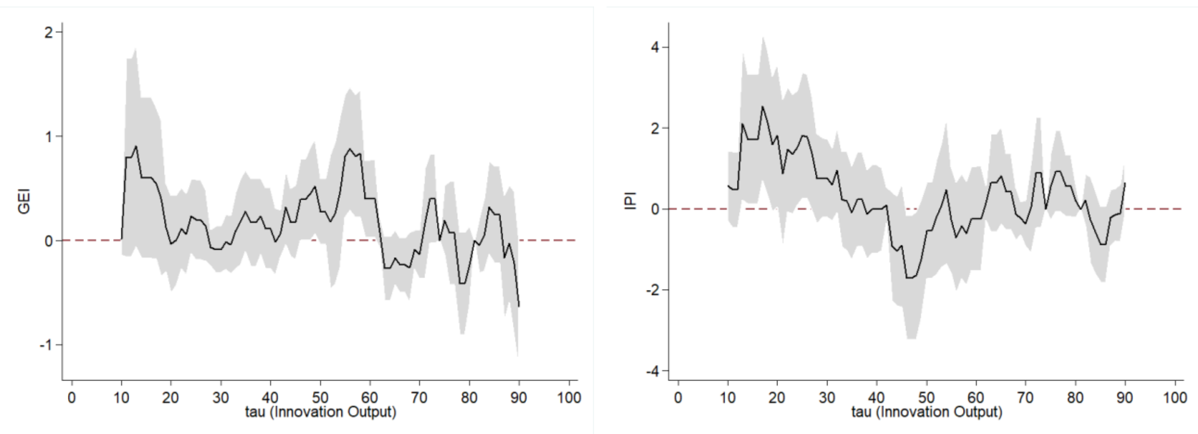

Figure 11. Effect of GEI and IPI on OUTPUT (controlling for time and country fixed effects)

Source: Authors' own (2019).

6. Conclusions

Three different models were estimated in pooling and in a panel structure with control for individual fixed effects and time. Evidence suggests that, in models (4) (5) and (6) in pooling, the entrepreneurship and intellectual property ecosystem positively affects the global innovation ecosystem.

The magnitude of the impact of the entrepreneurship ecosystem on the innovation ecosystem is greater in the lower quantiles, while the effect of the intellectual property ecosystem is greater in the higher quantiles. This is curious, since the upper quantiles of the innovation ecosystem depend more on the effect of the intellectual property ecosystem than the entrepreneurship ecosystem for the generation of global innovations. When we include a covariate of innovation inputs (model 5), there is an effect on the global production of innovative assets.

However, when we control for fixed individual and time effects in the model (4), the results indicate that the entrepreneurship and intellectual property ecosystems does not affect the countries' innovation ecosystem.

When we include the covariate of innovation inputs (model 5), it impacts together with the entrepreneurship and intellectual property ecosystem in the production of innovation in countries at specific quantiles. Furthermore, the effect remains when the model is estimated (6), which excludes innovation inputs.

In addition, the combination of a more robust entrepreneurship and intellectual property ecosystem and the relative increase in innovation inputs have not been efficient enough to generate a growing innovation environment for countries at all levels. In general, the application of the quantile regression method makes it possible to show precisely the non-linearity between the variables.

These results reveal the need for more effective policies to reverse the sterile results of the entrepreneurship and intellectual property ecosystem in innovation production. The structure of the entrepreneurship ecosystem and intellectual property regimes need to be improved so that creative efforts, skills, aspirations in conjunction with intellectual property protection are consistently rewarded with a large generation of intellectual assets.

This study contributes by providing evidence that the ecosystem of entrepreneurship, intellectual property and innovation needs to be improved. The construction of healthy ecosystems is a necessary condition for entrepreneurs, within an environment of protection of intellectual property, to increase the flow of innovation production in countries efficiently.

The present investigation has limitations as the study is restricted to the general results of the entrepreneurship, intellectual property and innovation ecosystem measured by the indexes. Our results refer to a relatively short period. The results are directly linked to the way the indexes are constructed and the indexes do not capture certain characteristics of ecosystems. Innovation outputs monitor legally protected innovations, but may not capture the real generation of innovations introduced by countries as well, for example, innovations in services, organizational, cultural production, among other aspects.

However, the GEI, IPI and GII constitute a strategic research source that generates relevant information for the management of entrepreneurship, intellectual property and innovation ecosystems. It is a useful database for decision makers. Another important aspect is that this work demonstrates the contribution that entrepreneurship and intellectual property can have on the production of innovation in countries, creating valuable information at a global level, with important use for policy makers.

We also emphasize that the evidence shown in this article must be contrasted with additional studies. As a suggestion for future work, alternative methodological approaches may inspire future research on the topic.

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APPENDIX A

Table 9. Geometric Growth Rate of Variables[1]

COUNTRY	IPI	GEI	GII	INPUT	GDP	OUTPUT	COUNTRY	IPI	GEI	GII	INPUT	GDP	OUTPUT
Algeria	5.64%	-4.77%	-0.66%	2.30%	0.37%	-7.60%	Malaysia	7.91%	0.06%	-1.86%	0.06%	3.89%	-4.64%
Argentina	5.14%	-8.57%	-1.76%	1.95%	-0.89%	-7.46%	Mexico	7.91%	-3.07%	-1.30%	0.47%	1.52%	-3.97%
Australia	7.35%	-1.48%	-2.28%	-0.17%	0.95%	-5.52%	Morocco	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Brazil	9.76%	-11.12%	-0.78%	1.34%	-2.16%	-4.44%	Netherlands	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Brunei Darussalam	14.55%	3.76%	-0.84%	2.44%	-1.71%	-11.41%	Nigeria	6.02%	-7.89%	0.24%	4.58%	-0.66%	-6.11%
Canada	11.09%	-0.34%	-0.83%	0.53%	0.87%	-2.83%	Pakistan	24.4%	10.6%	5.1%	8.8%	3.5%	-0.5%
Chile	5.60%	-2.00%	-2.89%	-0.38%	0.49%	-7.03%	Peru	8.95%	-4.70%	0.44%	2.48%	1.74%	-3.90%
China	13.20%	5.97%	3.65%	4.12%	6.36%	3.15%	Philippines	17.1%	-4.5%	14.6%	6.5%	5.1%	27.9%
Colombia	7.54%	-8.14%	-2.42%	-0.19%	1.49%	-6.50%	Poland	19.02%	3.06%	-0.82%	0.76%	3.95%	-3.22%
Costa Rica	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	Russian Federation	6.82%	-5.95%	-1.09%	2.04%	-0.75%	-5.88%
Ecuador	16.00%	-6.36%	-4.46%	-0.95%	-1.18%	-10.68%	Saudi Arabia	-3.1%	4.6%	-3.9%	-0.7%	-2.7%	-10.8%
Egypt	7.7%	-5.0%	1.1%	1.9%	2.0%	0.0%	Singapore	7.42%	-6.34%	-0.44%	0.02%	2.37%	-1.10%
France	7.86%	-0.07%	0.30%	0.89%	1.02%	-0.49%	South Africa	4.27%	-5.72%	-2.33%	0.30%	-0.25%	-6.87%
Germany	10.23%	1.07%	0.17%	1.79%	1.35%	-1.82%	Spain	18.6%	3.5%	-1.7%	0.2%	2.7%	-4.4%
Hungary	19.0%	27.0%	-1.0%	2.9%	4.4%	-5.6%	Sweden	16.85%	-3.57%	-0.12%	0.52%	1.07%	-0.89%
India	14.70%	-0.20%	3.64%	5.91%	6.50%	0.43%	Switzerland	10.51%	6.63%	0.47%	1.26%	0.45%	-0.39%
Indonesia	10.68%	5.48%	-0.07%	3.48%	3.70%	-5.24%	Thailand	14.35%	1.07%	0.35%	1.90%	2.47%	-1.81%
Ireland	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	Turkey	11.10%	-7.60%	-0.57%	2.07%	3.73%	-4.13%
Israel	14.22%	7.19%	3.22%	1.85%	1.72%	4.99%	Ukraine	5.15%	-6.94%	0.61%	1.03%	-1.32%	0.13%
Italy	19.83%	10.40%	-0.75%	0.31%	1.56%	-2.09%	United Arab Emirates	8.55%	-3.15%	1.27%	0.33%	2.50%	3.44%
Japan	10.45%	1.87%	0.31%	0.48%	1.16%	0.12%	United Kingdom	8.31%	1.61%	-0.44%	0.38%	1.47%	-1.47%
Jordan	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	United States of America	7.42%	0.53%	0.67%	1.29%	1.56%	-0.14%
Kenya	3.1%	7.7%	0.2%	3.3%	2.4%	-4.3%	Vietnam	14.03%	-2.52%	0.35%	2.27%	5.32%	-1.88%
Korea, Republic of	12.42%	2.85%	-0.32%	1.27%	2.45%	-2.45%							

Source: Authors (2019). Note: 1- The growth rate was calculated according to the availability of data for each country in the period.

APPENDIX B

MODEL 4

Table 10. Quantile regression results using pooled data (lagged variables)

GII	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
IPI	-0.0049	0.0912	0.0891	0.1301	0.3121***	0.7694***	0.5955***	0.4407***	0.2132*
	(0.121)	(0.143)	(0.123)	(0.106)	(0.105)	(0.135)	(0.154)	(0.153)	(0.121)
GEI	0.2780*	0.4248**	0.4284***	0.3357**	0.2921**	0.3168	0.3075*	0.1194	0.2322*
	(0.153)	(0.161)	(0.137)	(0.140)	(0.125)	(0.191)	(0.163)	(0.160)	(0.122)
GDP	0.0674	-0.0894	-0.0452	0.0622	0.0662	-0.0238	-0.0465	0.0106	-0.0715
	(0.124)	(0.113)	(0.101)	(0.094)	(0.079)	(0.081)	(0.073)	(0.076)	(0.054)

Source: Authors (2019). Asterisks denote the significance level: * 10%; ** 5%; *** 1%. Robust standard errors are given in parentheses.

Table 11. Quantile regression results controlling for time and country fixed effects (lagged variables)

GII	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
IPI	0.7885	0.4419	0.5886	-0.2327	1.0783	-0.3749	-0.2291	-0.3495	-0.0838
	(0.501)	(0.394)	(0.403)	(0.685)	(0.883)	(0.510)	(0.369)	(0.437)	(0.154)
GEI	0.1877	0.0622	-0.0572	0.0081	-0.0564	0.2119	-0.0279	0.2069	-0.1188
	(0.144)	(0.075)	(0.188)	(0.223)	(0.261)	(0.166)	(0.217)	(0.193)	(0.122)
GDP	-0.5414	-0.2433	0.5589	0.2190	0.1718	-0.5061	1.1329	-0.1202	0.1088
	(0.526)	(0.235)	(0.491)	(0.865)	(0.573)	(0.549)	(0.750)	(0.239)	(0.120)

Source: Authors' own (2019). Asterisks denote the significance level: * 10%; ** 5%; *** 1%. Robust standard errors are given in parentheses.

MODEL 5

Table 12. Quantile regression results using pooled data (lagged variables)

OUTPUT	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
LOGIPI	-0.5732*	-0.2624	-0.1500	0.0885	0.5178**	0.6449***	0.4890**	0.3526	0.3058*
	(0.300)	(0.212)	(0.216)	(0.285)	(0.223)	(0.204)	(0.230)	(0.234)	(0.155)
LOGINPUT	3.3159***	2.4783***	2.0661***	1.5843**	1.7856***	1.2082*	1.7408**	1.0212	0.0982
	(1.067)	(0.544)	(0.543)	(0.638)	(0.624)	(0.608)	(0.696)	(0.688)	(0.268)
LOGGEI	0.1044	0.2173	0.2254	0.3998*	0.1750	0.2698	-0.0119	0.2676	0.2834*
	(0.326)	(0.256)	(0.288)	(0.237)	(0.274)	(0.257)	(0.236)	(0.240)	(0.164)
LOGGDP	-0.5177**	-0.4432***	-0.3299**	-0.3521**	-0.4519**	-0.2547**	-0.2710**	-0.3174**	-0.0972
	(0.239)	(0.147)	(0.154)	(0.154)	(0.171)	(0.115)	(0.120)	(0.139)	(0.071)

Source: Authors' own (2019). Asterisks denote the significance level: * 10%; ** 5%; *** 1%. Robust standard errors are given in parentheses.

Table 13. Quantile regression results controlling for time and country fixed effects (lagged variables)

OUTPUT	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
LOGIPI	0.5491	1.8207*	0.7586	-0.0115	-0.5629	-0.2898	-0.3717	0.2002	0.6329
	(0.507)	(1.065)	(0.584)	(0.651)	(0.705)	(0.756)	(0.354)	(0.250)	(0.451)
LOGINPUT	0.8527	0.0130	-0.0357	0.4236	1.0674*	1.6432*	0.2955	-0.2205	0.7687
	(0.747)	(1.179)	(1.140)	(1.258)	(0.568)	(0.868)	(0.305)	(0.272)	(0.563)
LOGGEI	0.0478	-0.0353	-0.0843	0.1321	0.3173	0.4658*	-0.1210	-0.2420	-0.6049
	(0.102)	(0.297)	(0.133)	(0.235)	(0.204)	(0.244)	(0.132)	(0.233)	(0.364)
LOGGDP	-0.6701	-1.5895	0.8059	1.8009*	-0.9778	-2.2535*	0.3735	0.4641	0.1383
	(0.607)	(0.969)	(0.662)	(1.005)	(0.615)	(1.296)	(0.402)	(0.448)	(0.388)

Source: Authors' own (2019). Asterisks denote the significance level: ∗ 10%; ∗∗ 5%; ∗∗∗ 1%. Robust standard errors are given in parentheses.

MODEL 6

Table 14. Quantile regression results using pooled data (lagged variables)

OUTPUT	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
IPI	0.0771	0.2237	0.2552	0.3992	0.8680***	0.8818***	0.8304***	0.5528***	0.3250**
	(0.240)	(0.240)	(0.219)	(0.252)	(0.187)	(0.188)	(0.195)	(0.199)	(0.156)
GEI	0.6781**	0.6461**	0.5829**	0.6740***	0.4840*	0.4788**	0.2894	0.4443*	0.3004*
	(0.322)	(0.238)	(0.261)	(0.204)	(0.261)	(0.228)	(0.238)	(0.231)	(0.160)
GDP	-0.1731	-0.1857	-0.1153	-0.1875	-0.2663*	-0.1292	-0.0902	-0.2113**	-0.0870
	(0.291)	(0.185)	(0.175)	(0.156)	(0.158)	(0.102)	(0.107)	(0.100)	(0.069)

Source: Authors' own (2019). Asterisks denote the significance level: ∗ 10%; ∗∗ 5%; ∗∗∗ 1%. Bootstrapped standard errors are given in parentheses.

Table 15: Quantile regression results controlling for time and country fixed effects (lagged variables)

OUTPUT	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
IPI	0.5723	1.8211*	0.7576	-0.0000	-0.5339	-0.2453	-0.3636	0.1943	0.6537
	(0.524)	(1.067)	(0.585)	(0.661)	(0.715)	(0.780)	(0.345)	(0.246)	(0.457)
GEI	0.0156	-0.0358	-0.0829	0.1161	0.2770	0.4038	-0.1322	-0.2337	-0.6339*
	(0.092)	(0.284)	(0.134)	(0.235)	(0.191)	(0.224)	(0.139)	(0.226)	(0.369)
GDP	-0.4775	-1.5866	0.7978	1.8965*	-0.7368	-1.8825	0.4402	0.4143	0.3119
	(0.455)	(0.959)	(0.522)	(1.026)	(0.522)	(1.178)	(0.454)	(0.403)	(0.396)

Source: Authors' own (2019). Asterisks denote the significance level: ∗ 10%; ∗∗ 5%; ∗∗∗ 1%. Robust standard errors are given in parentheses.