Determinants of innovation performance of organizations in a regional innovation system from a developing country

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Abstract

Purpose – Variables affecting the innovation performance (IP) in regional innovation systems (RIS) have been widely studied in developed countries, while little information exists for the case of developing countries. Based on the innovation economics theory, this study aims to examine determinants of IP of organizations within the RIS of Medellin/Antioquia, Colombia (South America).

Design/methodology/approach – By using nonparametric statistical analyses, this study tests six research hypotheses through a randomly applied questionnaire, responded by 1,005 organizations belonging to the RIS of Medellin/Antioquia.

Findings – Results indicate that the economic sector, firm size, level of interaction with different parties and level of interaction with academic partners have a significant impact on IP in the RIS. Nevertheless, the number of employees in research and development and the adoption of new technologies have no significant effect.

Practical implications – Based on the results, this study identifies innovation determinants that managers and policymakers should consider when formulating strategies to improve organizations' IP. The result of this paper may provide valuable insights for the study of RIS' determinants and support further research in similar contexts.

Originality/value – This paper contributes to the limited body of knowledge regarding the variables that impact the IP of organizations in a RIS from a developing country. This paper also examines possible explanations for those hypotheses that were not supported, showing differences between developing and developed countries.

Keywords Innovation, Innovation performance, Organizational factors, Regional innovation system

Paper type Research paper

1. Introduction

Innovation economics theory states that "economic development is the result of appropriated knowledge, innovation and entrepreneurship operating within an institutional environment of systems of innovation" (Courvisanos and Mackenzie, 2014, p. 41). When aiming to achieve sustainable economic development, a critical problem faced by government policymakers and managers is how to build and improve traditional innovation systems, advance the development of organizational capabilities for innovation processes and increase innovation performance (IP) (Chen and Guan, 2012).

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For understanding innovation at a systemic level, it is important to consider innovation as a connected and complex phenomenon in which the context, the interactions among parties and the organizational variables clearly affect innovation outputs. Within the innovation economics theory, Cooke (1992) described a regional innovation system (RIS) as an interactive learning process among different types of organizations in a region, embedded in an institutional framework, whose aim is to enhance IP. Cooke *et al.* (1997) defined the IP of an RIS as the sum of innovation outputs of organizations within the system.

The regional innovation approach claims that regions represent an interesting potential observation site for innovation dynamics (Cooke *et al.*, 1997), and although many studies have focused on the diverse variables affecting the IP of RISs in developed countries, it is still necessary to understand this phenomenon in developing countries (Edquist, 1997).

According to the Oslo Manual (OECD, 2015a), the innovation system approach may focus on the study of firms in the context of the institutions, other organizations, value systems and social practices that affect their operation. Within this approach, as the firm is the main analytical unit, some regional innovation policies should be designed to stimulate innovation at the firm level. To improve competitiveness and to contribute to prosperity and growth, policymakers need to understand the importance of establishing an environment that supports innovation (Zenker, 2001, p. 207), and this environment might be achieved by means of institutional entrepreneurship (Hung and Whittington, 2011).

It is important to consider that within an innovation process, some activities may not be innately innovative, but they are prerequisites for the implementation of innovation (OECD, 2015a). Innovation processes and activities are important but, as stated by the OECD (2007), the IP (e.g. tangible results of innovation activities in the form of practical innovations) is the one that helps determine the competitiveness of organizations, regions and nations.

According to Kim (2014), assessing the IP and the variables influencing it is critical when considering different strategies to improve the innovativeness of companies within an RIS. The author said that it is important to define the metrics and factors that affect innovation, understanding their relevance and impact, therefore the assessment criteria need to be explored better. The OECD (2007, p. 28) also pointed the importance of understanding the metrics to identify factors influencing IP.

Evidence from emerging markets and economies, such as Singapore and South Korea, indicated that innovation might help developing economies increase their growth rates and their social and economic performance, especially when the institutional framework is solid and steady (Oluwatobi *et al.*, 2015), but according to Padilla-Perez *et al.* (2009), it is difficult to implement the activities needed to achieve IP, particularly in developing countries.

Few theoretical articles about IP exist, and no empirical research about the Medellin RIS or any other Colombian RIS was found. Most IP studies involved Asian, European and other developed countries, while few studies have focused on developing Latin American countries (Alcorta and Peres, 1998).

In this context, this research aims to examine important variables that affect the IP of organizations participating in the RIS of a developing country. The sample contains 1,005 randomly selected firms, a portion of the 2,725 firms that are part of the RIS of Medellin, Colombia (Ruta 2016). As the Innovation Pact is the best-known formal institution indicating the willingness of an organization to interact within the studied RIS, the database was extracted from the list of firms that have signed the pact. Further details about the Innovation Pact and its implications are provided in the Sampling and Data Collection section.

Medellin brings together a series of conditions that make the city an innovation laboratory for Colombia, with possible projection for other developing countries. Medellin was named the most innovative city in the world by the ULI in 2013 (Moreno, 2013), and since then, the region started a highly structured process to enhance its RIS, under an integral transformation project called Medellinnovation (2016), following the best practices of RISs worldwide. In the Innovation Cities Global Index 2015, released by 2thinknow, Medellin was named the city with the highest rate of innovation in the world, (2thinknow, 2015). In 2016, Medellin won the Lee Kuan Yew World City Award, for the innovative and sustainable urban development and solutions (IFHP, 2016). Finally, Damar's (2016, p. 6) study for the Inter-American Development Bank identified Medellin as "a major player in the area of evaluation of strategies of innovation".

Considering this, the present study formulated and empirically tested hypotheses, using nonparametric statistical procedures applied to a sample of firms located in the RIS of Medellin. Findings contribute to the literature by contrasting and extending prior theoretical predictions about an RIS in a developing country, helping to understand the relevant variables for IP in this context and identifying important insights to improve regional innovative outputs from the standpoint of managers as well as policymakers. Nonparametric, statistical analyses showed that the economic sector (ES), firm size (FS), the level of interaction (LI) with different parties and level of interaction academic partners (LIAP) significantly impact IP, while the number of employees in research and development (R&D) (ERD) and the adoption of new technologies (ANT) have no significant impact.

This paper is organized as follows: Section 2 introduces the conceptual framework, measures and hypotheses proposed for the study. Section 3 details the study's methodology and describes the research design, data collection and analysis. Section 4 presents the results of the analysis, discussing the tested hypotheses and results. Finally, Section 5 concludes the study, highlighting important findings, suggesting future research and noting policy implications.

2. Theoretical background and hypothesis

"Innovation is the process of converting knowledge and ideas into a benefit value" (Chen and Guan, 2012, p. 103). In innovation economics, innovation is analysed from a systemic point of view, as a system of relationships and interactions between different parties, with an emphasis on the structural conditions, the institutions within the system and the linkages among these institutions (Jiao *et al.*, 2016). In recent years, the system of innovation approach has been increasingly applied to the analysis of innovation activities in both national and regional contexts (Cooke *et al.*, 1997; Lundvall, 1992; Edquist, 1997).

Considering this, the present study focuses on understanding determinants of IP of participant organizations of the RIS of Medellin. Based on existing literature of different academic authors in the field of innovation economics, and supported by these previous studies, this paper considers six indicators that measure the output of IP: (a) the ES, (b) the LI with other parties, (c) the LIAP, (d) the FS, (e) the ERD and (f) the ANT. These variables, their acronyms and their unit measurements are shown in Table 1.

In this study, the IP was measured by whether or not a company made a product innovation, a process innovation, an organizational innovation or a marketing innovation during a given period. Measurement procedures were similar to those used by Chang (2003), Paas and Poltimäe (2010), Serrano-Bedia *et al.* (2017) and Vega-Jurado *et al.* (2009).

Table 1.
Variables included in the analysis

Variable	Full name	Measure
IP	Innovation performance	Number of products, processes, organizational or marketing innovations made by the firm over a defined period
ES	Economic sector	Number of innovations in a sector (farming, commerce, communications, building, financial, industrial, mining/energy, services and transportation)
LI	Level of interaction	Number of interactions in innovation projects, such as advice or support from a consultant, a company or a research group; collaboration with local, national or international universities; and adaptation of a technology from another company
LIAP	Interaction with academic partners	Number of interactions with local, national and international universities
FS	Firm size	Number of employees in a firm
ERD	Employees in R&D	Number of employees in an R&D department
ANT	Adoption of new, external technologies	A dummy variable that takes the value of 1 if a company develops innovations using technologies adapted from other firms and 0 otherwise

2.1 Economic sector

Because some sectors innovate more than others, the ES is an important variable used to analyse IP (Gault, 2018). As the market environment where firms compete (Malerba, 2005), the ES provides a mid-level link between organizational and an institutional or regional levels. According to Fritsch and Slavtchev (2011), resources allocated to the services or agricultural sectors are less effective in terms of IP than those allocated to the manufacturing sector (European Commission, 2017; Eurostat, 2013; OECD, 2017). Therefore, organizations in the industrial sector should generate higher levels of IP than organizations in other sectors. The following hypothesis is proposed:

H1. Organizations in the industrial sector generate higher IP than organizations in other economic sectors.

2.2 Level of interaction and interaction with academic partners

Because cooperative relationships with other parties may affect organizational R&D activities in various ways (Fritsch, 2002), interaction is a crucial variable of analysis when examining a system's innovative performance. RIS efficiency is strongly influenced by the type, intensity (Howells, 1999) and quality of interactions and exchanges between its different parties (Fritsch and Slavtchev, 2011). Cooke's (2002) research has shown that regional and external interactions among firms and other organizations in the innovation process impact regional innovation results. Likewise, some studies of RIS focused on the importance of reliance and cooperation to enhance information sharing and knowledge spillovers, which foster sustainable innovation economies (Cooke, 2004; 2005). According to Li (2012), to stay competitive, organizations need to collaborate with governments, universities and research institutes to develop innovation. High LI, with numerous parties, produces active R&D (Feldman *et al.*, 2005; Fritsch, 2002). In addition, according to Jiao *et al.* (2016), the LI of actors within the RIS is critical in determining the system's innovative capacity.

When focusing on how firms interact with academic organizations in the innovation process, Diez (2000) affirmed that universities and research institutes support local firms' innovation efforts. Similarly, Fritsch and Slavtchev (2011) stated that private sector firms'

LIAP strengthens IP. To foster and enhance innovation, universities and firms need to interact to promote innovative activity (Jaffe, 1989; Villasana and Chavez, 2012), as organizations involved in these types of cooperation generate higher levels of innovation (Chang, 2003; Hagedoorn and Cloodt, 2003). In general, greater interaction between organizations in developing innovation projects leads to better IP, especially when the interactions involve academic partners. The following hypotheses are proposed:

H2. The LI has a positive effect on IP.

H2a. LIAP has a positive effect on IP.

2.3 Firm size and the number of employees in research and development

Howells (1999), among other authors, considered the relationship between FS and IP. Size is measured as the average number of employees in a company (Fritsch and Slavtchev, 2011). Over the years, several explanations regarding FS' positive effect on innovative activity and performance have been offered (Pereira *et al.*, 2016). According to Hall and Rosenberg (2010), size is correlated with the availability and stability of internally generated funds.

The literature suggests that high population density should correlate with innovation activity, because it enhances the opportunity for contact and cooperation (Feldman, 2000; Fritsch, 2002; Fritsch and Slavtchev, 2011). Additionally, according to Christopherson and Clark (2007), the greater reach of large firms in governance institutions, labour markets, government policy and research institutions allows them to take advantage of RIS resources, thereby increasing their IP. In the same line, Audretsch (2004) suggested that small firms are restrained from innovating because they eschew necessary risks to pursue large gains and have a low capacity to develop, commodify and commercialize research outputs.

Regarding R&D departments, Fritsch and Slavtchev (2011) opined that "the greater the number of R&D employees, the greater the opportunity to find a suitable partner for cooperation and knowledge exchange". According to Howells (1999) R&D employment has had a noticeably positive impact on RIS efficiency, and the intensity of R&D activities affect the IP of both public and private firms in an RIS.

Following these studies, the following hypotheses about FS and ERD are proposed:

H3. FS is positively related to IP.

H3a. ERD is positively related to IP.

2.4 Adoption of new external technologies

Adaptability, defined as the tools and skills needed to modify technologies, in accordance with organizational settings and local economic, technical and social contexts, is an important component for innovation (Zanello *et al.*, 2016). According to these authors, "innovation carries a different connotation in low-income countries context in comparison to industrialised economies" (Zanello *et al.*, 2016, p. 885). In these countries, assimilation and ANT are important foundations for the innovation process. Other studies have shown that in certain cases, information, system adoption, technological transfer and ANT are necessary for innovation (George and Lin, 2017; Lawrence and Davies, 2015). According to Lawrence and Davies (2015), small, initially marginal innovations and technological adaptations open up new opportunities and stimulate greater IP, then:

H4. The ANT has a positive effect on IP.

Considering all the variables in this analysis, a theoretical model is shown in Figure 1.

3. Methods

3.1 Sampling and data collection

The study analysed data obtained from 1,005 firms, out of a total of 2,725 firms that signed the Innovation Pact of Medellin's RIS (Ruta 2016), since 2014 until 2018. Identifying the signatory organizations of the Innovation Pact was a practical way to define the boundaries of an RIS. The pact was a voluntary, formal agreement, and firms that signed it recognized the importance of networking and innovation for future economic development and were committed to participate in innovation systems (Ruta 2018). Furthermore, signing the pact indicated that the organization participated in the RIS, had an innovation leader inside the organization and committed that by 2021 it will invest at least 3% of its revenue internally into science, technology and innovation (Wade, 2016, p. 1).

A simple random sampling technique was used; Ruta N digitally collected data during 2016 and assured that the sample selected was representative of the entire population. Following Ángel-Gutiérrez (2007), the statistically significant size of the sample was defined from the following expression:

$n_1 = \frac{n\ N}{N\ +\ n\ -\ 1}$, where $n = \left[\frac{Z(1-\alpha/2)}{E_0}\right]^2 \widehat{\Pi}\left(1-\widehat{\Pi}\right)$, and a statistically significant sample could be reached with only 377 organizations, thus, a sample of 1,005 was sufficient for the study. The response rate was 36.8%, as 1,005 of 2,725 firms completed the questionnaire.

It is important to acknowledge that Ruta N is the primary, public, regional innovation intermediary, formed in 2009, with a mandate to apply and implement the *2011–2021 Strategic Science Technology and Innovation Plan*, which aims to "transform Medellin into the Latin American capital of innovation" (OECD, 2015b, p. 12). In studies related to an RIS' innovation, various authors have collected information at the firm level (Belussi *et al.*, 2010; De Marchi and Grandinetti, 2017;

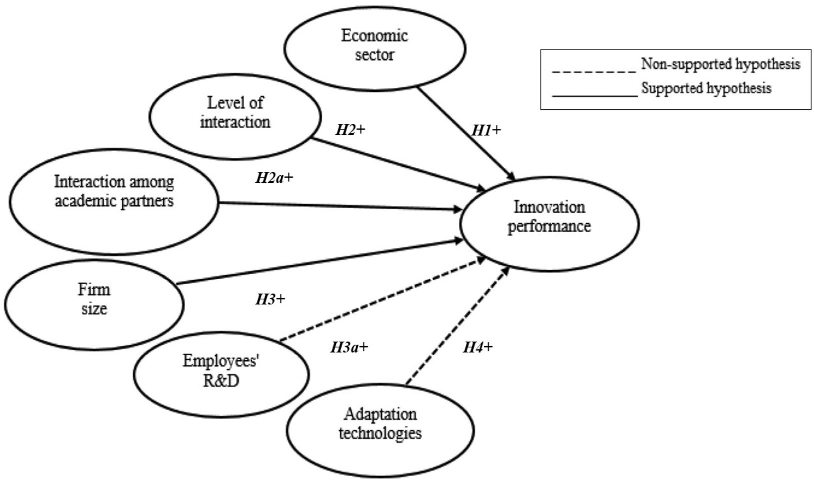

Figure 1.
Theoretical model

Schmiele, 2012). This study includes measures from firms and excludes other types of organizations (such as governmental, academic or civil society organizations).

3.2 Data analysis

The survey contained questions concerning companies' background, the selected variables about the innovation process and the IP results (see Appendix). The variables included in the study, and their operational constructs, are shown in Table 1. To test hypotheses, different procedures were used, as summarized in Table 2.

In Table 2, θ_i is the population's average variable for level i, where i, j = levels of the variable of interest, ρ is the population's Pearson correlation coefficient between variables of interest and ρ_{pb} is the population's point biserial correlation coefficient.

For *H2*, *H2a*, *H3*, *H3a* and *H4*, the two tests validated whether or not these correlations are significant. These hypotheses are exhibited in Figure 2.

4. Results

For *H1*, one parametric test that compares the means between two or more independent samples is the single-factor between-subjects analysis of variance, which is based on the following assumptions:

- each sample has been randomly selected from the population it represents;
- the distribution of data in the underlying population from which each of the samples is derived is normal; and
- variances of k underlying populations represented by k samples are equal to one another.

If any of these assumptions are violated, the reliability of the computed test statistic may be compromised. If one or more assumptions are violated, the nonparametric, analogue Kruskal–Wallis one-way analysis of variance by ranks test can be used (Sheskin, 2003). In this study, the first assumption for variance analysis is accomplished, but the last two assumptions do not hold. Table 3 shows descriptive statistics for the variables included in the analysis.

For *H1*, Table 4 shows that variables are not normally distributed, and variables' variances are not homogeneous (Levene's test for homogeneity of variance, p-value = 0.5039), then the use of a nonparametric test is mandatory.

Concerning *H2*, *H2a*, *H3* and *H3a*, the Pearson product-moment correlation coefficient test is based on the following assumptions:

Hypotheses	Tests	Contrast
H1	Kruskal–Wallis	$H_0 : \theta_i = \theta_j, \forall_{i \neq j}$ $H_1 : \exists \theta_i \neq \theta_j$
H1	Bonferroni method	$H_0 : \theta_i = \theta_j$ $H_1 : \theta_i \neq \theta_j$
H2, *H2a*, *H3* and *H3a*	Pearson correlation coefficient	$H_0 : \rho \geq 0$ $H_1 : \rho < 0$
H4	Point biserial correlation coefficient	$H_0 : \rho_{pb} \geq 0$ $H_1 : \rho_{pb} < 0$

Table 2. Hypothesis testing

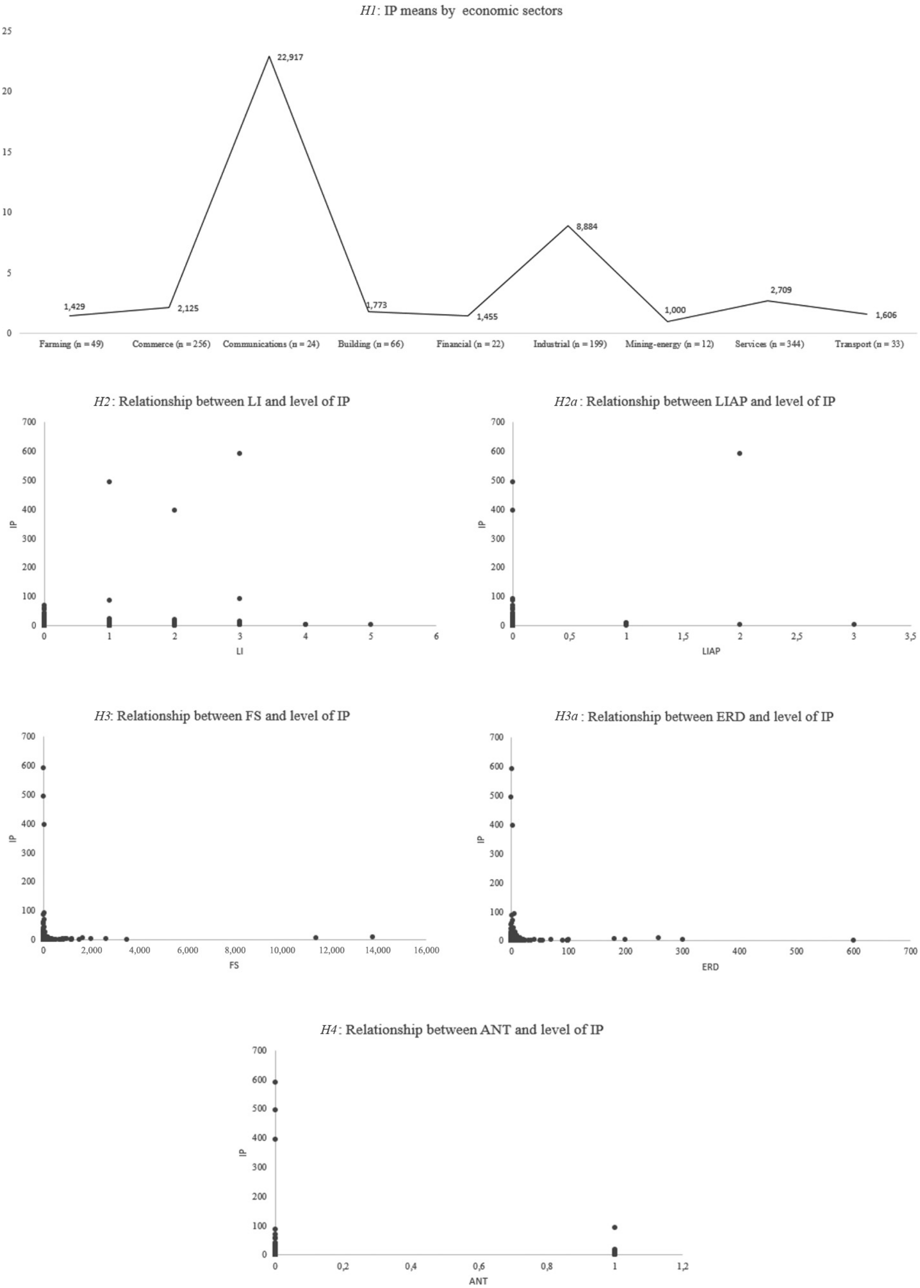

Figure 2.
Relationships evaluated using four hypothesis tests

Variable	Absolute frequency	Mean	SD
ES			
Farming innovations	70	1.429	2.236
Commerce innovations	544	2.125	5.008
Communications innovations	550	22.92	100.7
Building innovations	117	1.773	2.535
Financial innovations	32	1.455	4.091
Industrial innovations	1,768	8.884	50.93
Mining/energy innovations	12	1.000	1.595
Services innovations	932	2.709	6.420
Transportation innovations	53	1.606	3.691
LI			
Zero interactions	684		
One interaction	231		
Two interaction	66		
Three interactions	21		
Four interactions	2		
Five interactions	1		
Total innovations	4,078	4.058	27.95
LIAP			
Zero interactions	990		
One interaction	12		
Two interactions	2		
Three interactions	1		
Total innovations	4,078	4.058	27.95
FS			
Total employees	77,272	76.89	594.5
Total innovations	4,078	4.058	27.95
ERD			
Total employees	3,782	3.790	25
Total innovations	4,078	4.086	28.05
ANT			
Adopters	64		
Non-adopters	941		
Total innovations	4,078	4.058	27.95

Table 3.
Descriptive statistics for each variable

ES	*p*-value
Farming	$= 1.85e^{-09}$
Commerce	$<2.2e^{-16}$
Communications	$= 3.379e^{-10}$
Building	$= 1.421e^{-09}$
Financial	$= 1.552e^{-08}$
Industrial	$<2.2e^{-16}$
Mining/energy	= 0.0003752
Services	<2.2e-16
Transportation	= 1.188e-09

Table 4.
The Shapiro–Wilk normality test

- the sample of n subjects for which it is computed is randomly selected from the population it represents;
- the level of measurement of each variable is an interval or a ratio;
- the two variables have a bivariate normal distribution; and
- distributions do not exhibit characteristics of autoregression or autocorrelation (Sheskin, 2003).

Regarding *H4*, the point biserial correlation coefficient is a special case of the Pearson product-moment correlation coefficient, used when one variable is expressed as interval/ratio data and the other variable is represented by a nominal/categorical scale (Sheskin, 2003). The Pearson correlation is extremely robust with respect to violations of assumptions (Norman, 2010), which is the reason for using a parametric test rather than a nonparametric test for these hypotheses.

H1 was supported with a p-value of 0.002 (<0.01), which means that the null hypothesis is rejected at confidence level of 99%. Thus, there is no evidence to accept that average innovations are equal for the nine sectors. Results indicate that average innovations in the commerce and industrial sectors are significantly and statistically different (significant difference of −88.0215). A negative difference means that average innovations are greater for the industrial sector.

H2 and *H2a* were both supported with a p-value of 0.000 (<0.01), which means that the null hypotheses were rejected at confidence level of 99%. Thus, a statistically significant correlation does exist between them with these confidence levels, meaning that LI and LIAP are positively related to IP.

H3 was supported with a p-value of 0.000 (< 0.01), which means that there is a statistically significant correlation between the number of employees and level of innovation at 99% confidence level. Because the correlation coefficient is positive (0.491), a direct relationship exists, supporting the hypothesis that FS is positively related to IP.

H3a and *H4* were not supported by the data, with a p-value of 0.866 and 0.697 (>0.01), respectively, which means that the null hypothesis is accepted at confidence level of 99% in both cases. Thus, there is no statistically significant correlation between the number of ERD, the ANT and the IP level.

5. Discussion

This study's outcome suggests that the ES is conducive to IP and it is higher for firms related to the industrial sector. This result was supported by Fritsch and Slavtchev (2011) and by reports from the European Commission (2017) and Eurostat (2013). When analysing the role of the ES in IP, however, it is important to understand distinctions caused by context. For example, the European Commission's (2018) most recent study about the European Union IP reported that the services sector was more dynamic than the manufacturing sector. These contrasting results might be explained by the importance of the industrial sector to developing economies. By contrast, innovative activity in developed economies, with strong service sectors, is focused on more dynamic, adaptable, knowledge-intensive services, which generally have lower fixed costs than manufacturing industries.

The results also suggest that both the LI and the LIAP positively affect a firm's IP, a finding widely supported in other empirical studies (Cooke, 2002; Feldman *et al.*, 2005; Fritsch and Slavtchev, 2011; Howells, 1999; Li, 2012). However, even though the LI exerts a positive influence on IP, the correlation coefficient (0.164) shows that this relationship and the hypothesized effect of LI on IP are weak. The same situation occurs for the LIAP's effect on IP, which shows a somewhat stronger but still weak correlation coefficient of 0.246. An article by Belussi *et al.* (2010) provides one explanation for this to happen, by noting the costs of joint network management, internal R&D and possible leaking of information between collaborating partners within an RIS, especially when the complexity of the innovation strategy increases.

An RIS' IP is influenced not only by the LI but also by the type and quality of exchanges between the different parties. While not included in this study, the issue is relevant for future research, as it has been measured in previous studies, but none of them provide enough insightful data to strategically manage interactions and collaborations in the innovation process.

FS is directly related to IP, which suggests that firms with a higher number of employees should present higher levels of innovation. Similar conclusions were presented in Christopherson and Clark (2007), Feldman (2000), Fritsch (2002) and Fritsch and Slavtchev (2011). More research on this specific question should be undertaken, partly because some previous empirical studies noted greater innovation activity in smaller firms than in larger ones. Some authors argued that small firms' light and flexible structures are a competitive advantage in the innovation process (Cohen and Klepper, 1996; Hicks and Hegde, 2005; Terziovski, 2010). Freel (2000), in contrast, opined that FS does not affect innovation. Other authors focused on how new manufacturing processes, manufacturing technologies and financing alternatives affected the IP of small firms, suggesting that these mechanisms progressively allow small firms to achieve greater innovation results (Ahluwalia and Mahto, 2018; Deakins and Bensemann, 2018; Su *et al.*, 2016). Future innovation studies may include not only FS but also particular dynamics and internal interactions that influence variables affecting the organizational structure.

This paper's results showed no statistically significant correlation between the number of ERD and a firm's IP. While this deviates from our anticipated outcome and from the literature, it is line with the research of Gao *et al.* (2018), whose study found no statistically significant relationship between R&D investments and the number of patents in new technology. These results can be partially explained by the unpredictability of returns on investment in innovation activities, the characteristics and structure of R&D teams, and as supported by Coad *et al.* (2016), riskier R&D investments. Typically, more important than the number of ERD departments is their quality (Dakhli and De Clercq, 2004), their skills (González *et al.*, 2016) and their ability to work in a team (Poo, 2015). On the other hand, this result could be attributed to the sample, which is located in a developing country and is characterized by relatively small R&D departments, especially compared to those in developed countries.

Finally, findings indicate that the ANT factor is not significantly related to organizations' IP. Several articles discuss the relationship between technological adoption and innovation (Danquah and Amankwah-Amoah, 2017; Lanzolla and Suarez, 2012). Lanzolla and Suarez (2012, p. 836) stated that "a firm may readily subscribe to a new technology but then fail to use it". Thus, although one might expect this variable to be more relevant in the case of developing countries, in this study, no relationship was found between this variable and IP, perhaps because new technologies are not always adopted for long term. Alternatively, companies also adopt new technologies to improve processes or to reduce costs, and not to carry out innovation.

6. Conclusions

RIS in developing countries must be examined and differences must be discussed for academic purposes, as developing countries provide interesting academic insights, which could differ from RIS in developed countries, which have stronger institutional frameworks and preconditions in which RIS operate.

Based on a sample of 1,005 organizations within the RIS of Medellin, Colombia, the study identified some differences between the determinants of IP of organizations in an RIS of this developing country with that of organizations in developed countries, previously explored in the literature. Findings indicate that the size of the economy, FS and LIAP all affect the IP levels of companies in the Medellin RIS. The number of ERD department and the adaptation of new, external technologies were not associated with IP.

The ES that presented higher level of IP in the Medellin RIS was the industrial sector. Similar results might be observed in developing countries other than Colombia, which are transitioning from industrial-based economies to high-value, knowledge-intensive service economies. Studies of European countries indicate higher innovation levels in the services sector.

The results also suggested that larger firms produce greater IP than smaller ones. This may be because of these organizations' structural and financial capacity to support internal innovation processes. This situation could change with new production technology, improved production processes and financing methods, such as crowdfunding, which finances small companies quickly.

Interactions between RIS participants and academic partners undeniably affect IP. This proved to be true for organizations in the Medellin RIS, as well as for RIS considered in previous studies. However, the effect of these variables on IP is not as broad as one might expect, possibly because of high collaboration costs in developing countries, where the lack of trust requires a more formal process that can delay completion and increase costs.

The number of R&D employees did not statistically correlate with the IP of participant firms in the RIS. This may be explained by a similar effectiveness regardless of size or by characteristics of specific cases. Additionally, R&D departments of firms in this RIS are generally small, and there is no reliable way statistically to compare performance differences with minimal variability.

Finally, contrary to expectations, the ANT did not relate significantly to IP, especially in a developing country where technological adoption is considered an enabler of innovation. This result may be explained by a lack of continuity, where new technology does not support innovation, especially when it is not useful or not successfully implemented over the long run. Additionally, it is possible that many firms adopt new technologies to improve general performance and not to pursue innovation.

Policymakers aiming to improve RIS should take into account the current disadvantage of small companies regarding innovation and provide means to overcome the shortcomings of capital and internal capacity that often restrict their absorption capability, which still prevents them from taking advantage of RIS dynamics. To lead in IP, future system improvements must be leveraged into the industrial sector. This will be necessary to develop future knowledge-intensive and high value-added services sector that can compete in global markets.

Institutional entrepreneurs must take into account the importance of interaction and collaboration as a central dynamic of an RIS, promote its impact and help reduce costs and legal procedures associated with joint projects. Cooperation and trust in RIS should remain a central objective of the government.

This study helps understand some variables related to the IP of organizations in a developing country's RIS, opening new possibilities for future studies. Valuable, cross-national studies should compare how relevant factors affect the IP of firms within RISs embedded in developed, developing and underdeveloped countries and understand the reasons for such differences. Finally, future research should measure IP not only by the number of innovations or patents but also by its impact. The tool now used to measure IP, the Community Innovation Survey 2018, does not distinguish between different impact levels of innovations (Eurostat, 2017).

The study has some limitations. Firstly, self-reported data from a survey was used, which can result in inaccurate information or bias in the data collected. For IP, the research measured the number but not the economic value of innovations achieved by firms. All types of innovation were considered as equal, even though a radical innovation from one company can represent a larger achievement than numerous incremental innovations from another.

The selected tests also have limitations. The Kruskal–Wallis test cannot single out differences if the null hypothesis is rejected. It tests only for differences that are collectively significant (Chan and Walmsley, 1997). A significant disadvantage of the standard Bonferroni method occurs when more than one component of HO is false. This test is less effective with detecting more than one false HO (Rice, 1989). A correlative finding does not reveal which variable influences another, the reason why the causation cannot be statistically determined or if a third unknown variable might be causing both (Holland, 1986).

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Appendix. Questionnaire wording

Has your firm signed the N. Ruta's innovation? Yes___ No___

In which economic sector does your firm operate?

Farming	____	Commerce	____
Communications	____	Building	____
Financial	____	Industrial	____
Mining-Energy	____	Services	____
Transportation	____		

How many employees currently work for the firm? _____

How many employees are in the R&D department? _____

How many product innovations did the firm make between 2016 and 2017? ____

How many process innovations did the firm make between 2016 and 2017? ____

How many organizational innovations did the firm make between 2016 and 2017? ____

How many marketing innovations did the firm make between 2016 and 2017? ____

How many innovation projects were carried out in alliance with or with help from each of the following partners between 2016 and 2017?

With advice or support from a consultant ____

In conjunction with another company or research group ____

In collaboration with local universities ____

In collaboration with national universities ____

In collaboration with international universities ____

By adapting other companies' technologies ____

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