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Editorial

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Los desafíos de la innovación en Latinoamérica

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Introducción

Actualmente, la innovación es considerada un imperativo estratégico para alcanzar el desarrollo económico y es la mejor opción para enfrentar los desafíos del futuro. Por ello, el estudio y el análisis de sus resultados constituyen una actividad relevante para el mundo académico, para el diseño de políticas públicas y para las revistas que difunden dicha información.

Uno de los referentes más importantes en esta materia es el Índice Global de Innovación (GII)1. Este informe, proporciona valores detallados sobre el desempeño de la innovación en 129 economías del mundo. Sus 80 indicadores aportan una visión amplia de la innovación, lo que incluye al entorno político, la educación, la infraestructura y la sofisticación del mercado entre otros.

Una de las grandes conclusiones del último GII 2019 es que, a pesar de la incertidumbre y la desaceleración de la economía global, el mundo ha experimentado un fuerte aumento de las inversiones en innovación.

En los pasados dos años (2017-2018), el uso de la propiedad intelectual (PI) alcanzó cifras récord. Los gastos globales en I+D se duplicaron entre los años 1996-2016 y crecieron vertiginosamente por sobre el promedio de la economía mundial. En el año 2017, los gastos globales de los gobiernos en I+D en base a su PIB aumentaron en cerca del 5%. Por otra parte, los gastos en I+D de las empresas crecieron en un 6,7%, el mayor incremento reportado desde el año 2011 (GII, 2019).

Otro dato interesante del informe 2019 es el auge de las economías de ingresos medios. Países como Corea del Sur y China destacan entre los 20 países más innovadores del mundo. Otros países experimentaron un fuerte ascenso como los Emiratos Árabes Unidos (36.º), Tailandia (43.º), la India (52.º), Filipinas (54.º); que in-gresó dentro de los 55 primeros, y la República Islámica de Irán (61.º); que se acerca a los 60 primeros (GII 2019).

¿Qué ocurre en Latinoamérica?

Desafortunadamente, Latinoamérica sigue estancada respecto del desempeño promedio de las economías globales. Solamente Costa Rica -país de ingresos medios altos- sostiene resultados por encima de sus expectativas económicas. Países de ingresos altos como Chile, Uruguay y Argentina se mantuvieron en concordancia a su nivel de desarrollo. Lo mismo ocurrió con países de ingresos medios altos como Colombia, Brasil y México. Por otro lado, países de ingresos medios bajos como Bolivia, Paraguay y Guatemala, lamentablemente estuvieron por debajo de sus expectativas de crecimiento económico (GII, 2019).

Para JOTMI, la discreta posición de los países latinoamericanos no es una novedad. En el año 2014 publicamos un número especial en el que discutimos con Heitor y col., el rol del cambio tecnológico y las políticas de innovación en Latinoamérica. En aquella oportunidad fuimos muy críticos. La región no ha sido eficiente en promover la innovación en el sector productivo. En términos generales, las políticas de fomento en Latinoamérica no consideran a la empresa como foco del proceso de innovación. Sus instrumentos de apoyo son poco claros, extremadamente burocráticos y descontinuados en el tiempo (Heitor y col., 2014)

También nos planteamos la pregunta ¿puede Latinoamérica avanzar después de una década perdida? Nuestra reflexión nos llevó a argumentar la necesidad de crear redes de valor que potencien el desarrollo inclusivo, las trayectorias de aprendizaje y principalmente la cooperación. Para lo anterior, era necesario realizar inversiones públicas efectivas orientadas a internacionalizar a las universidades y fortalecer la atracción de capital humano avanzado entre otros (Heitor y col., 2014).

Uno de los artículos más citados para en caso chileno, fue el trabajo que publicamos con Horacio Gonzalez en el que criticamos la falta de una política pública destinada a insertar laboralmente a los nuevos investigadores (Gonzalez & Jiménez, 2014). Actualmente, el principal agente empleador del capital humano avanzado en Chile continúa siendo la universidad (79°). El sector empresarial chileno contrata menos del 5,5% de los doctorados, mientras que la administración pública menos del 2% (Encuesta ANIP[2], 2018). Estos datos no son prometedores y reflejan los pilares más débiles exhibidos por Chile en el último GII 2019: Un insuficiente *capital humano e investigación* (57°) que produce bajos resultados en *tecnología, nuevo conocimiento* (61°) y *creatividad* (66°) (GII, 2019).

[1] Global Innovation Index 2019 (GII).
[2] Inserción laboral de investigadores, Informe de resultados: 2da Encuesta de Inserción de Investigadores con Postgrado. Centro de Estudios ANIP (2018). http://www.anip.cl/informe-insercion-2018

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Presentación a la edición especial

La presente edición de JOTMI es el resultado de *un llamado a publicar* realizado por Cristian Geldes, Christian Felzensztein y Alejandro Flores a finales del 2018. Ellos sostienen que la mayoría de los estudios en innovación están centrados en economías desarrolladas y advierten, además, que la literatura especializada de la región es relativamente escasa (Ketelhöhn y Ogliastri, 2013; Olavarrieta y Villena, 2014). También afirman que los factores que determinan la innovación en las empresas y sectores industriales de la región obedecen a dinámicas propias y no siempre son comparables a los países desarrollados (Brenes et al, 2016; Geldes et al, 2017a; Heredia et al, 2018[a]).

En este sentido, la presente edición confirma en términos generales lo planteado por Geldes y col (2018). Se observa un profundo interés por el desarrollo de conocimiento específico orientado a Latinoamérica, con nuevos enfoques y nuevas realidades.

A continuación, se presentan 12 artículos que fueron seleccionados a partir de 29 trabajos provenientes de Argentina, Brasil, Chile, Colombia, Ecuador y Uruguay. Su orden y agrupación responde a tres dimensiones:

- Primero, una mirada desde la empresa, en donde se abordan las capacidades ambidiestras de las mismas, el rol de los sindicatos en la innovación empresarial, la relación de la cooperación interorganizacional en la innovación, y como la innovación se relaciona con el desempeño exportador.
- La segunda dimensión, incluye una perspectiva sectorial de la innovación, abordando temas como la gestión de portafolios innovadores en la academia, los servicios intensivos en conocimiento, los conocimientos base para la innovación en los sistemas de información y tecnológicos, y el efecto de las innovaciones de marketing en el sector de manufacturas.
- Por último, en la tercera dimensión se desarrolla un enfoque más sistémico con temas como los ecosistemas de emprendimiento, el efecto de las fallas de mercado en la inversión en innovación y los subsidios a la innovación.

Estamos muy contentos y satisfechos por la gran convocatoria que tuvimos con este número especial. Estamos seguros de estos artículos recibirán muchas citas y serán un valioso insumo para el diseño de políticas públicas en la región.

En nombre de la Facultad de Economía y Negocios de la Universidad Alberto Hurtado, queremos agradecer a todos los editores, revisores y especialmente a sus autores. Gracias por elegir a JOTMI como un medio para difundir sus investigaciones.

Santiago de Chile, diciembre, 2019.

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Exploration and Exploitation in Latin American Firms: The Determinants of Organizational Ambidexterity and The Country Effect

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Abstract: In this article, we explore the determinants of organizational ambidexterity across Latin American countries -Chile, Ecuador, and Peru- from innovation surveys of 2,786 manufacturing companies. The study introduces valuable information on ambidextrous organizations in emerging economies, contrasting to traditional literature frequently focusing on developed countries. Findings confirm the importance to measure ambidexterity in a multidimensional perspective, relating exploration to radical innovation, and breaking down exploitation into incremental exploitation, related to incremental innovation and repetitive exploitation related to operational efficiency. This work also finds that higher GDP per capita relates to higher exploration and exploitation ability of firms and supported our hypotheses that political and economic uncertainty of each country impact on organizational ambidexterity. Additionally, we expand on Diaz-Molina´s model (2018), on the relationship between strategic and operational absorptive capacity on ambidexterity by validating his findings across several countries and uncovering a positive interaction term between strategic and operational absorptive capacity when both impact on ambidexterity.

Keywords: ambidexterity; innovation; absorptive capacity; country environment; emerging economies

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1. Introduction

As some studies suggest, the actual objective of companies is to remain competitive and to thrive in the long-term, and this purpose is possible when organizations become ambidextrous (Levinthal and March 1993; March 1991). In other words, firms should focus on their ability to exploit their current capabilities while simultaneously exploring fundamentally new competencies.

Concepts of "exploration" and "exploitation" have increasingly dominated organizational analyses of technological innovation, organizational adaptation, or organizational learning. Studies have identified many antecedents to ambidextrous firms in developed countries (Piao and Zajac,2016; Jansen et al., 2009; Lederman, 2010); however, little research has examined the Latin-American context.

Accordingly, the primary purpose of this article is to analyze the determinants of organizational ambidexterity in emerging economies, specifically, companies from Latin American countries - Chile, Ecuador, and Peru-.

This paper examines the effect of the country-specific environment on the development of ambidextrous organizations. According to Crespi & Zuñiga (2012), determinants of innovation are not the same across countries; in other words, there is a diversity of innovative behavior among countries in Latin America. Simsek (2009) argues that environmental factors might exert influences on ambidextrous firms; for this reason, companies 'strategy include external contingencies.

Validating the concept of organizational ambidexterity as a three-dimensional construct as proposed by Piao & Zajac (Piao & Zajac, 2016); we find that Latin-American companies are better-off implementing organizational ambidexterity practices through exploration (radical innovation), incremental exploitation (incremental innovation) and repetitive exploitation (operational efficiency).

Additionally, the present study contributes to filling a gap in the literature on the direct effect of country-specific characteristics in organizational ambidexterity. Controlling by GDP per capita, there is evidence to suggest that ambidexterity is more spread in countries with better economic situation.

Finally, we expand on Diaz-Molina´s model (2018), on the relationship between strategic and operational absorptive capacity on ambidexterity by validating his findings across several countries and uncovering a positive interaction term between strategic and operational absorptive capacity when both impact on ambidexterity.

The rest of the paper is structured as follows, the second section provides a brief overview of the literature and develops hypotheses on organizational ambidexterity. The third section outlines the methodology used for the study and provides sample descriptive statistics. Next, the econometric results of the study are presented along with a discussion, conclusions and contributions.

2. Literature Review and Hypotheses

2.1 Exploration and exploitation in organizational ambidexterity

Generally, an ambidextrous organization is defined as "the ability of an organization to both explore and exploit with the aim of competing in mature technologies and markets where efficiency, control, and incremental improvement are prized and to also compete in new technologies and markets where flexibility, autonomy, and experimentation are needed" (O'Reilly and Tushman, 2013, p. 324).

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According to this definition, the relation between exploration and exploitation is the crucial characteristics of ambidexterity. Exploration/Exploitation dichotomy has been associated with different organizational dimensions. The term of exploration is commonly related to the acquisition of new knowledge through learning and innovation. Meanwhile, the term of exploitation refers to the use of prior knowledge for searching efficiency (Gupta, Smith, & Shalley, 2006).

On product innovation, Piao and Zajac (2016) define exploitation as the repetition and incremental refinement of a firm's existing products aimed at improving existing product-market domains. Meanwhile, exploration is the development of new products aimed at entering new product-market domains in terms of knowledge. Vermeulen and Barkema (2001) linked exploration as the search for new knowledge and exploitation as the continuing use of a firm's past knowledge base.

Several studies suggest that ambidexterity is positively associated with firm performance, specifically sales growth (O'Reilly and Tushman, 2013; Auh & Menguc, 2005; Han & Celly, 2008; Venkatraman et al., 2006). For this reason, a main area of research has been to identify the requirements to balance the tension between exploration and exploitation, a central issue of ambidextrous organizations.

According to this, the current research recognizes different ways to achieve ambidexterity. One mechanism is known as "sequential ambidexterity" which proposes sequencing changes in the structure to promote temporary periods of exploring and exploiting (Siggelkow and Levinthal, 2003). Another mechanism is "architectural ambidexterity" related to a dual organizational structure where simultaneously some units would be specialized in explorations and others in exploitation; each unit has a different process, culture, and dynamics (O'Reilly and Tushman 2008). Finally, an individual dimension to manage this tension is known as "contextual ambidexterity," which is referred to as the ability to deploy alignment—exploitation—as well as adaptability—exploration—throughout a business unit, requiring organizational support and individuals able to make judgments about alignment and adaptability simultaneously(Gibson and Birkinshaw, 2004).

Nevertheless, O'Reilly and Tushman (2013) analyzed different studies to conclude that these modes of ambidexterity are potentially viable and complementary. Indeed, firms may use combinations of sequential, architectural, or contextual ambidexterity according to the nature of the market faced. The key is to determine the rates of exploration and exploitation required over time,

Piao and Zajac (2016) recognized exploitation that could impel exploration. Additionally, the authors introduced three dimensions of organizational ambidexterity: exploration, incremental exploitation, and repetitive exploration. "Incremental exploitation" is the creation of new designs for existing products, and "repetitive exploitation" is the repetition of existing designs for existing products that could potentially impede exploration. For the objectives of this article, the approach proposed by Piao and Zajac is used to measure ambidexterity.

2.2. Innovative behavior among Latin American and developed economies

Most studies about organizational ambidexterity and innovation have focused on developed economies with less emphasis on emerging markets such as Latin America, representing a gap in the systematic investigation of these constructs process (Heredia Pérez et al., 2019).

Studies have shown that in comparison with other regions, the economic growth of Latin America has been unsatisfactory with stagnant productivity levels being the most urgent challenge (Crespi et. al., 2017; Álvarez and Grazzi, 2018; Zahler et al., 2018). Consequently, these studies have suggested the importance of innovation to improve productivity, applying technological advances to lead more effective use of productive resources, and the transformation of new ideas into new economic solutions (Crespi and Zuñiga, 2012).

Extant research identifies informality in the innovation process, focus on imitation and technology acquisition rather than R&D, fewer resources devoted to innovation activities, and fragmented flows of information within national systems of innovation as the main differences between Latin America and developed countries' innovation practices (Crespi and Zuñiga, 2012; Heredia Pérez et al, 2019; Geldes et al., 2017)..

These different practices and the fact that innovation performance increases faster in developed economies warrants a more detailed view of organizational ambidexterity in Latin America. (Lee, Özsomer,& Zhou, 2015).

2.3. The impact of the country environment on organizational ambidexterity

The extent to which environment determines organizational ambidexterity remains poorly understood. Simsek (2009) postulates a multilevel model of organizational ambidexterity, where environmental factors moderate the effect of ambidexterity on firm performance. The author proposes that an organization's strategy can be designed in terms of its fit or congruence with the environmental contingencies facing the organization.

For example, in environments with little dynamism, the need to introduce new innovations is not necessary for enhancing performance because the organization might benefit more by being exploitative. In contrast, organizations in dynamic environments must be strategically flexible and efficient because customers need, and competitor activities demand, immediate action (Sidhu et al., 2004).

Regarding the environment's aspects, Jansen et al. (2006), indicated that pursuing exploratory innovation is more effective in dynamic environments, whereas pursuing exploitative innovation is more beneficial in more competitive environments. Patel et al. (2012) reported that ambidexterity is mediating the relationship between environmental uncertainty and firm performance. As a result, ambidextrous companies are more likely to be able to both refine existing resources and develop new competencies in an uncertain environment. Meanwhile, firms that lack ambidexterity are less likely to respond effectively to environmental demands.

Crespi & Zuñiga (2012) report that determinants of innovation are not the same across countries, showing the diversity of innovative behavior. Exploitation – related to process innovation- is more frequent than exploration -related to product innovation-, due to the preponderance of capital goods and machinery in innovation investment. Additionally, it is important to recognize that environments in Latin American region differ between countries and; for instance, countries like Argentina, Chile and Uruguay, with active innovation policies have better results in innovation rate than other countries in the region. In emerging economies, firms adjust strategies to the dynamic external environment to remain competitive by balancing exploration and exploitation activities (Heredia Pérez et al.,2019).

An interesting element in the debate is the impact on innovation of some political and economic uncertainties due to some Latin America's faulty institutions. Geldes et al. (2017) concluded that companies use diverse strategies such as interpersonal ties, networking and partnership alliances and review the firm's boundaries to deal with uncertain environments.

Accordingly, one of the objectives of this article is to analyze the effect of country environment on organizational ambidexterity. Studies focusing on ambidextrous organizations have failed to explain the role of country-specific characteristics in this phenomenon, especially their direct effect. Companies face contingencies specific to each country, which develop uncertain or stable conditions to define firms´ strategies for their exploitation and exploration activities.

Considering that R&D spending, innovation, productivity, and per capita income reinforce each other, sustaining long-term growth (Hall and Jones 1999; Rouvinen 2002), we postulate that countries with better economic situation, using GDP per capita as proxy, generate better conditions to develop ambidextrous organizations. Accordingly, the hypotheses to be tested are:

H1. Better country´s economic situation increases the exploratory component of organizational ambidexterity.

H2. Better country´s economic situation increases the exploitative component of organizational ambidexterity.

Additionally, we postulate that political and economic uncertainty impact organizational ambidexterity.

H3. Higher country's political and economic uncertainty decreases the exploratory component of organizational ambidexterity.
H4. Higher country's political and economic uncertainty decreases the exploitative component of organizational ambidexterity.

2.4. The impact of absorptive capacity on organizational ambidexterity

Another objective of this paper is to expand on prior research on the relationship between absorptive capacity and ambidexterity (Diaz-Molina,2018). Absorptive capacity is the ability of a firm to recognize, assimilate, and apply new knowledge, and it is considered paramount since new competitive advantages will very likely come from outside sources (Cohen & Levinthal, 1989; 1990). The original work by Diaz-Molina was tested only on Chilean firms, we contribute to the validity of the model by diversifying the source of firms including three additional countries.

Regarding a strategic dimension, absorptive capacity is observed as strategic learning, improving the innovation performance of the firm (Lin et al.,2016). Therefore, using and integrating external knowledge, a firm could acquire a competitive advantage in new products and markets, in other words, in exploration (Chen et al., 2011; Lin et al., 2016). Moreover, in the case of incremental innovation, Diaz-Molina (2018) proposed that external knowledge is used for the creation of new designs for existing products. According to Lichtenthaler (2009), technological knowledge is the knowledge the firm explores, but also exploits, identifying application and commercialization opportunities. Consequently, we can formulate the following hypotheses:

H5. Higher strategic absorptive capacity increases the exploratory component of organizational ambidexterity
H6. Higher strategic absorptive capacity increases the exploitative component of organizational ambidexterity.

Regarding operational dimension, absorptive capacity is observed as the skill of a firm's internal units to acquire, assimilate, and transform external information. Patel et al. (2012) suggested that operational absorptive capacity can influence the firm's ability to rapidly analyze and act on changes to the operational environment like changes in demand and quickly increasing the range and mobility of machines, labor, and material. Therefore, companies could understand how to perform innovation on new products and processes implementation, which is closely associated to exploration and exploitation activities. Consequently, we expect that:

H7. Higher operational absorptive capacity increases the exploratory component of organizational ambidexterity.
H8. Higher operational absorptive capacity increases the exploitative component of organizational ambidexterity.

Finally, another aspect understudied has been the complementary relation between strategic and operational absorptive capacity, when both capabilities impact the organizational ambidexterity of companies. Some studies have reported that not only external but also internal dimension of absorptive capacity are complementary, interrelated, and necessary (Zahra and George, 2002; Harris and Lee, 2018; Chesbrough, 2005). For this reason, it is possible to infer that acquisition and assimilation of external knowledge are influenced by internal units of company that transform this kind of information. In turn, the development of these internal units is conditioned by the scope of external sources that support innovative activities.

H9. There is a potential complementary effect between strategic and operational absorptive capacity when both impact on the organizational ambidexterity.

3. Methodology

3.1. Data

Regarding the objectives of this research, we conducted an exploratory quantitative study based on secondary data available from three Latin American countries: Chile, Peru, and Ecuador. We used the National Innovation Survey of each country, which is performed at the firm level, follows the OECD guidelines included in the Oslo Manual (Organisation for Economic Co-operation and Development, 1997).

One of the values of this study has been the collection of data compatible and comparable across countries. For this purpose, the OECD guidelines included in the Oslo Manual was a relevant help, because countries -given certain limitations- used the similar sampling methodologies, questionnaire design, and data processing.

The dataset includes data from the 2014-2016 period. Our analysis only covers manufacturing companies, achieving a final sample of 2,786 companies, made up of 1,439 companies from Peru, 950 companies from Ecuador and 397 companies from Chile.

3.2. Dependent Variables

Based on Diaz-Molina (2018) and Piao & Zajac (2016), we considered organizational ambidexterity as a multidimensional concept with three dimensions to measure: exploration, incremental exploitation, and repetitive exploitation. The exploratory function of ambidexterity is measured by identifying the product innovation of the firm. According to OECD guidelines, product innovation is the introduction to the market of a new good or service, or a significantly improved good or service, regarding its characteristics or its use. In this study, we used two dichotomic questions to measure exploration: If the company is succeeded in introducing new goods to the market (Yes/No) or if the company is succeeded in introducing new services to the market (Yes/No). Thus, a polychoric procedure was conducted before the factor analysis. The results were rotated for a better fit, and the factor is found to be representative. Table 1 summarizes the resulting loadings for the relevant factor. Exploration is represented by one underlying factor encompassing 201% of the total variance.

Incremental exploitation is measured by identifying the marketing innovation of the firm. According to OECD guidelines, marketing innovation is the introduction to the market of significant changes in product design or packaging, product placement, product promotion, or pricing. In this study, we used four dichotomic questions to measure incremental exploitation: If the company is succeeded in introducing significant changes in i) the design or packaging; ii) advertising; iii) distribution; or iv) pricing. Factor analysis is conducted on these four dichotomous variables using the same methodology as before. One factor is found to be representative (i.e., eigenvalue greater than 1.0) explaining 109% of the variability and is defined as incremental exploitation.

Repetitive exploitation is represented by five questions covering process innovation (improvements in manufacturing and logistics methods) and organizational innovation (introduction of decision making, external relations, and process design practices). Factor analysis is conducted on these five dichotomous variables using the same methodology as before. One factor with an eigenvalue higher than one were retained explaining 105% of the variability.

3.3. Theoretical Variables

Strategic absorptive capacity was derived from a factor analysis conducted on a set of questions from the survey addressing the external sources firms reach out to for purposes of their innovation activities (Díaz-Molina, 2018). The external sources are classified as market (i.e., suppliers, customers, competitors, and consultants), institutional sources (i.e., universities and research facilities), and others (i.e., conferences, publications, professional associations, and the internet). Answers to these ten questions were dichotomous (YES/NO). Thus, a polychoric procedure was conducted before the factor analysis. The results were rotated for a better fit, and the factors with an eigenvalue higher than 1.0 were retained covering 91% of the total variance.

Operational absorptive capacity is defined as the ability of the firm to reach outside its boundaries for operational knowledge (i.e., engineering, operational, information systems). Since an innovation survey is the source of the data utilized, no direct question is related to this type of knowledge. A proxy is used following Setia & Patel (Setia & Patel, 2013), by assuming that the firm has established engineering and information systems departments and that these departments would reach out for the state-of-the-art practices in each area in order to improve operations. Again, three questions with dichotomous answers are used in the questionnaire to cover this area. The same procedure as the one used for strategic absorptive capacity is used to determine the relevant factors. One factor recorded an eigenvalue higher than 1.0, covering 125% of the total variance. Table 1 summarizes the resulting loadings for the relevant factor.

Studies show a virtuous circle in which R&D spending, innovation, productivity, and per capita income mutually reinforce each other and lead to long-term, sustained growth rates (Hall and Jones 1999; Rouvinen 2002). Therefore, to measure the impact of the country environment on organizational ambidexterity, we use GDP per capita as scalar variable related to the economic situation of each country. The mean of the three analyzed countries is 14.7 dollars. Additionally, we used dummies for each country.

3.4. Control Variables

Potential confounding effects were controlled by including various relevant sets of dichotomic variables. Training is considered as an essential capability for the assimilation of knowledge, particularly in the international arena (Lane, Salk, & Lyles, 2001). The variable cooperation those companies that innovated in collaboration with other entities. Additionally, included exportation as dummy variable if the companies declared exportation activities or not. Other two dummy variables are introduced in the model: internal sources of information; and acquisition of equipment, machinery or software. To account for firm size, we included the natural logarithm of the number of employees.

3.5. Statistical Methods

A multivariate regression model is used to analyze the relationship between strategic absorptive capacity, operational absorptive capacity and country variables (i.e., the independent variables) and exploration, incremental exploitation, and repetitive exploitation (i.e., the dependent variables). A multiple analysis of variance test is performed before the multivariate regression model to test whether or not the independent grouping variable simultaneously explains a statistically significant amount of variance in the dependent variables. The Wilk's Lambda U test, the Lawley-Hotelling test, the Pillai test, and Roy's Largest Root test are performed.

As mentioned above, factor analyses have been conducted using the polychoric correlation matrix in all cases since the underlying variables were all dichotomous (Netter, Wasserman, & Kutner, 1990).

Table 1. Factor Analysis for Two Independent Variables and Three Dependent Variables

	Strategic Absorptive Capacity		**Operational Absorptive Capacity**		**Exploration**		**Incremental Exploitation**		**Repetitive Exploitation**	
	Loading		**Loading**		**Loading**		**Loading**		**Loading**	
Survey Item	Factor 1	Communality	Factor 1	Communality	Factor 1	Communality	Factor 1	Communality	Factor 1	Communality
External Market Sources of Information:										
Suppliers	0.72	0.47								
Customers	0.73	0.45								
Competitors	0.74	0.40								
Consultants	0.78	0.39								
External Institutional Sources of Information:										
Universities	0.86	0.25								
Research Institutes	0.84	0.29								
External Other Sources of Information:										
Conferences	0.83	0.30								
Publications	0.86	0.25								
Professional Associations	0.86	0.25								
Internet	0.80	0.35								
IS as a Dpt. of the Firm			0.71	0.50						
R&D as a Dpt. of the Firm			0.74	0.46						
Eng. as a Dpt. of the Firm			0.70	0.50						
The Firm launched a new product in 2014					0.47	0.78				
The Firm launched a new service in 2014					0.47	0.78				
Marketing Innovation in:										
Packaging							0.74	0.44		
Advertising							0.83	0.31		
Distribution							0.88	0.23		
Pricing							0.80	0.36		
Process and Org. Improvement in:										
Manufacturing									0.72	0.48
Logistics									0.75	0.43
Process Design									0.83	0.30
Decision Making									0.80	0.35
External Relations									0.81	0.34
Eigenvalue	6.59		1.54			0.44	2.65		3.09	
% of Total Variance	91		125			201	109		105	

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4. Results

Table 2 presents descriptive statistics and correlations for the study variables. Table 3 presents the results of the regression analyses for organizational ambidexterity -exploration, incremental exploitation, and repetitive exploitation-. To evaluate heteroscedasticity and multicollinearity on the model, a run was performed with robust standard errors, variance inflation factors were below 5, and tolerance value was higher than 0.1; hence, it was assumed that it was viable to use the aforementioned variables in the analysis (Field, 2013). Moreover, predictor variables are not highly correlated.

Table 2. Descriptive Statistics and Correlation Matrix

	Mean	s.d.	1	2	3	4	5	6	7	8	9	10	11
1. Exploration	0.13	0.19	1.00										
2. Incremental Exploitation	0.12	0.25	0.31	1.00									
3. Repetitive Exploitation	0.16	0.26	0.36	0.48	1.00								
4. Strategic Absorptive Capacity	0.38	0.33	0.14	0.16	0.17	1.00							
5. Operational Absorptive Capacity	0.16	0.26	0.23	0.19	0.22	0.19	1.00						
6. N° workers Log	3.97	1.54	0.10	0.10	0.19	0.14	0.55	1.00					
7 Training	0.25	0.44	0.26	0.18	0.28	0.15	0.20	0.11	1.00				
8. Cooperation	0.61	0.49	0.16	0.14	0.10	0.30	0.07	0.05	0.11	1.00			
9. Internal sources of information	0.48	0.50	0.13	0.17	0.19	0.35	0.19	0.14	0.13	0.15	1.00		
10. Acquisition equipment	0.52	0.50	0.27	0.15	0.25	0.00	0.10	0.08	0.23	0.15	0.06	1.00	
11. Export	0.33	0.47	0.06	0.07	0.10	0.16	0.35	0.49	0.08	0.06	0.10	-0.01	1.00

Source: National Innovation Survey of Chile (Décima Encuesta de Innovación de empresas 2015-2016. Ministerio de Economía, Fomento y Turismo); Peru (Encuesta nacional de innovación en la Industria manufacturera 2015. Instituto Nacional de Estadísticas e Informática; Ecuador (Encuesta nacional de actividades de innovación 2015. Instituto Nacional de Estadísticas y Censos).

The baseline model (Model 1 for the three dependent variables) includes control and absorptive capacity variables. Model 2 includes the interaction term between strategic and operational absorptive capacity on the organizational ambidexterity; meanwhile, Model 3 adds the impact of GDP per capita and Model 4 adds dummies for countries -Peru and Ecuador-. Performing a likelihood ratio test (LRT) for each model, results indicate a statistically significant improvement in model fit.

In model 1, it is possible to observe that the coefficients for strategic and operational absorptive capacity are positive and significant for the dependent variables. Strategic absorptive capacity has direct effect on exploration ($\beta = 0.03$, $p < 0.01$), incremental exploitation ($\beta = 0.06$, $p < 0.01$) and repetitive exploitation ($\beta = 0.07$, $p < 0.01$). Operational absorptive capacity has a stronger effect on these variables ($\beta = 0.12$ on exploration and incremental exploitation; $\beta = 0.08$ on repetitive exploitation) at the 0.01 level. Hence, the influence of absorptive capacity is stronger on exploitation than exploration.

In model 2, there is a positive interaction term between strategic and operational absorptive when both impact on incremental exploitation ($\beta = 0.14$, $p < 0.01$) and repetitive exploitation ($\beta = 0.07$, $p < 0.05$); additionally, the effects on exploration is less stronger ($\beta = 0.05$, $p < 0.1$) .

In model 3, results indicate a positive and significant effect of GDP per capita on exploration ($\beta = 0.003$, $p < 0.01$), incremental exploitation ($\beta = 0.005$, $p < 0.01$) and repetitive exploitation ($\beta = 0.02$, $p < 0.01$); however, this effect does not seem stronger than other predictors in the model. As we expected about control variables, there is a positive and significant effect of cooperation, training, internal sources of information, and acquisition of equipment, machinery or software. In Model 4, results indicate a negative impact on ambidexterity for companies from Peru and Ecuadorwith the effect on repetitive exploitation stronger than the effect on exploration and incremental exploitation.

Overall, the analysis provides various interesting outcomes. First, Hypothesis 1 to 4 are supported in regression analysis. Regarding results, it is possible to consider the effect of country variables on organizational ambidexterity: the direct impact of GDP per capita and dummies of each country.

On the other hand, results provide support for Hypothesis 4 to 8, regarding the impact of absorptive capacity on organizational ambidexterity. Additionally, Hypothesis 9 is supported by exploitation innovation and exploration innovation, which means that when companies work with existing and new products, there is a complementary effect of strategic and operational absorptive capacity.

5. Discussion, implications and limitations

This study contributes to the existing investigation of organizational ambidexterity in several ways. It provides a more in-depth examination of the determinants of organizational ambidexterity in emerging economies, specifically, Latin American companies; introducing valuable information about an under-researched region and contrasting to traditional literature which frequently focuses only on developed countries. This contribution is seemed crucial, when the most of Latin American countries develop incremental innovation with little or no impact on international markets, mostly based on imitation and technology transfer (Crespi & Zuñiga, 2012).

Table 3 Linear Regression Analysis

	Exploration				Incremental Exploitation				Repetitive Exploitation			
Parameter	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model4	Model 1	Model 2	Model 3	Model 4
Intercept	0.09***	0.09***	0.13***	0.09***	0.04**	0.03***	0.04**	0.06**	0.01***	0.01***	0.01***	0.12***
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Strategic Absorptive Capacity (SACAP)	0.03**	0.02**	0.04***	0.02**	0.06***	0.05***	0.06***	0.04***	0.07***	0.05***	0.09***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.2)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Operational Absorptive Capacity (OACAP)	0.12***	0.12***	0.11***	0.12***	0.12***	0.10***	0.10***	0.11***	0.09***	0.08***	0.07***	0.08***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Cooperation	0.04***	0.04***	0.05***	0.04***	0.04***	0.05***	0.07***	0.07***	0.01	0.01	0.07***	0.08***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Exports	-0.01	-0.01	0.00	-0.01	-0.00	-0.01	-0.01	-0.01	-0.01	0.00	0.00	-0.03**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Information internal sources	0.02***	0.03***	0.02**	0.03***	0.06***	0.07***	0.07***	0.06***	0.07***	0.07***	0.06***	0.05***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Acquisition equipment	0.09**	0.09***	0.09***	0.09***	0.06***	0.06***	0.06***	0.08***	0.11***	0.11***	0.12***	0.12***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Training	0.07***	0.07***	0.07***	0.07***	0.06***	0.07***	0.067***	0.07***	0.11***	0.12***	0.11***	0.12***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N° of workers log	-0.01**	-0.01**	-0.01**	-0.01**	-0.00	-0.01	-0.01	-0.01	0.02**	0.02***	0.01**	0.01**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
SACAP × OACAP		0.05*	0.06*	0.05*		0.17***	0.13***	0.16***		0.11**	0.11**	0.09**
		(0.03)	(0.03)	(0.03)		(0.04)	(0.04)	(0.04)		(0.04)	(0.04)	(0.04)
GDP per capita			0.003***				0.005***				0.02***	
			(0.02)				(0.01)				(0.01)	
Peru				-0.05***				-0.03				-0.14***
				(0.05)				(0.02)				(0.01)
Ecuador				-0.03*				-0.09***				-0.26***
				(0.01)				(0.02)				(0.01)
Adjusted R2	0.17	0.17	0.17	0.17	0.17	0.10	0.10	0.11	0.17	0.17	0.21	0.21
Log-likelihood	***	*	***	***	***	***	***	***	***	***	***	***
N companies	2,786	2,786	2,786	2,786	2,786	2,786	2,786	2,786	2,786	2,786	2,786	2,786
N countries	3	3	3	3	3	3	3	3	3	3	3	3

*p<0.1; **p<0.05;***p<0.01.

5.1. Implications to theory

First, based on findings of Diaz-Molina (2018) and Piao and Zajac (Piao and Zajac,2016), the study confirms the importance to measure ambidexterity in a multidimensional perspective, considering that exploration dimension refers to radical innovation. Meanwhile, exploitation could be incremental as incremental innovation, or repetitive as operational efficiency. Most studies have analyzed ambidexterity through a dichotomic definition - exploration versus exploitation-, but this new approach comprehends the inherent complexity of an ambidextrous firm.

Second, this research provides insights into the direct effect of country environment on organizational ambidexterity. A limited number of researches has examined this relation, focusing in the mediator role of environment in the effect of ambidexterity on firm performance (Auh and Menguc, 2005; Jansen et al., 2006; Simsek, 2009). According to this, findings of our regression analysis show that country variables such as GDP per capita impact exploration and exploitation ability, supported our hypotheses about the positive influence of better economic and political situation of each country: if companies face particular contingencies created by each country, certain o stable conditions could impulse firms´ strategies for innovative activities.

Third, it is possible to recognize that strategic and operational absorptive capacity has a positive and significant effect on ambidexterity, providing a better understanding of the ability of a firm to recognize, assimilate, and apply new knowledge for generating new competitive advantages. Besides, it is possible to confirm the findings of Diaz-Molina (2018) in emerging economies, observing that the effect of the operational dimension is stronger than strategic dimension aspect. Therefore, it seems that the skill of a firm's internal units to acquire and transform external information is more important than the strategy of reaching these external sources.

Additionally, companies conduct innovation knowledge separately from operational or efficiency best practices. However, the study confirms that the simultaneous application of both types of knowledge contributes positively to the exploration, incremental exploitation and repetitive exploitation within the firm. This finding will allow management to become more successful in its overall innovative efforts.

Regarding control variables, it is possible to observe a positive effect of training, cooperation, internal sources of information; and acquisition of equipment, which is coherent with literature in developed economies.

5.2. Practical implications

Our findings suggest several important managerial implications. Managers tend to treat innovation knowledge separately from operational or efficiency best practices. This study shows that the simultaneous application of both types of knowledge contributes positively to the radical and incremental innovation within the firm. This finding will allow management to become more successful in its overall innovative efforts.

Also, managers should prioritize investments in the acquisition, assimilation, and transformation of knowledge; acquiring knowledge internally through cross-functional work and frequent interactions with other departments, or externally, across a range of stakeholders including customers, suppliers, and trade partners (Patel et al.,2012). The key is to develop organizational learning capabilities to achieve competitive advantages.

The findings of this study is coherent with Heredia Pérez et al (2019), Latin American managers should develop the capacity to combine exploration and exploitation, because ambidextrous firms tend to outperform other in uncertain environment. Indeed, these authors recommended combine internal and external resources in environment of low institutional quality; meanwhile in positive institutional environment firms are able to be ambidextrous without a greater dependence on external cooperation.

5.3. Policy implications

Finally, the findings support the promotion of innovation programs in Latin America, especially thosefocused on the development of innovation knowledge and operational best practices. Indeed, legislation that incentivize R&D and innovation at the firm level has proven very effectiveThe effect of tax incentives in R&D and innovation (R&D+i) has been extensively studied, and there is evidence that 1% increment in private R&D+I expenditure increases a country's productivity growth by 0.13% (Guellec & van Pottelsberghe de la Potterie, 2002).

5.4. Limitations and future research directions

Despite the positive results of this study, there are several limitations on the findings which are related to the absence of relevant control variables of the firm such as sector, age or size. This situation is due to the limited access to complete data sources for the three countries under study.

Future research is needed to acquire a comprehensive picture of organizational ambidexterity in Latin American companies. Additionally, it is interesting to investigate other relation that literature has postulated including the impact on performance of ambidexterity and absorptive capacity. On a final note, an effort should be made to improve the dataset of Latin American companies to include key descriptive variables and service companies.

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The relationship between Unions and Innovation in Chile

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Abstract: This article examines how and to what extent unions affect companies' innovation in Chile. It contributes to the existing literature in the following two aspects: First, because it widens the scope of analysis focusing in a developing country that is characterized by some specificities regarding the innovation as well the union landscape. Second, because it provides more in-depth analysis, taking into account the effect of unions on the four different types of innovation proposed in the Oslo Manual by OECD. Results show that unions do not affect product and process innovation while influence organizational innovation and marketing in a non-linear way

Keywords: Labor unions, Trade unions, Innovation, Chile.

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1. Introduction

Innovation is nowadays widely recognized as a central driver of economic growth and development for companies and countries. In consequence, many companies and many governments are putting innovation at the center of their strategies leading and motivating research to understand better what is innovation and what determines and fosters it. For this purpose, in the last decades, innovation has been defined and analyzed at the firm as well as the systemic level, though most of the studies take place in developed countries and on the manufacturing and the high technology industries (Geldes et al .2017b). Moreover, previous studies have used different definitions, classifications, and types of innovation, leading to some confusion in the field. In this context, OECD reached consensus when proposing an innovation's classification in the Oslo Manual. Specifically, this manual considers the following definition: *"innovation is the implementation of a new or significantly improved product (good or service), of a process, marketing method, or a new organizational method in business practices, workplace organization or external relations"* (OECD, 2006, p. 56). This definition introduced four different types of innovation: product innovation, process innovation, marketing innovation, and organizational innovation. Where product innovation and process innovation are closely related to the concept of technological developments, marketing innovations are strongly related to pricing strategies, product package design, product placement, and promotion activities, and, finally, organizational innovations are strongly related to the business practices. After the acceptance of this definition, the Global Innovation Index (GII) was created in 2007 to provide a framework to measure innovation. In particular, this index is evolving in each edition, aiming to capture the multi-dimensional facets of innovation by providing a rich database of detailed metrics for 126 economies. However, even though this index contemplates so many metrics that influence innovation, there are still variables that are not considered and have not received the merited attention. From our point of view, this is the case of the unions. Specifically, the omission of this variable in the GII and its scarce attention by the academic community[1], may undermine the private and public initiatives that draw on these analyses to promote innovation, especially in companies or countries with high union density or union participation.

There is evidence that shows unions can have a significant impact on innovation; however, if its impact is positive or negative is still a matter of discussion. On the one hand, some studies argue that unions may affect the ability of companies to innovate, basically because they reduce the control over the workplace, and increase the cost of labor limiting so the resources available to innovate. On the other hand, studies state that unions can have a positive effect because they force or persuade companies to compete based on innovation instead of competing based on low cost.

This article examines how and to what extent unions affect companies' innovation in Chile and contributes to the existing literature in the following two aspects: First, because it widens the scope of analysis focusing in a developing country that is characterized by some specificities regarding the innovation as well the union landscape. Regarding innovation, as Geldes & Felzensztein, (2013) and Geldes et al. (2017b) show, Chile shares common problems related to innovation with other Latin American and emerging countries as the late adaptation of innovation, the effects of exogenous technological change, informality on the process of innovation, an adaptive and incremental nature of innovation, the lack of coordination with the national innovation and middle and lower levels of social capital that implies some difficulties to the formation of innovation networks. Regarding unions, Chile is characterized because 1) Union density is higher than in the US (where most of the studies have taken place)[2], 2) Chile presents a slight growth in this indicator since 2000 (while in Europe and the US this indicator has decreased over the last decade)[3]. This increase has been interpreted as

[1] For instance, in Web of Science, only 3 of the 2434 papers that are focused on "product innovation", also refer to "unions"
[2] According to the ILOSTAT, in 2016, the union density attained 10.3% in the US, while 19.6% in Chile. The database is available at https://www.ilo.org/ilostat/. Consulted 25 March 2019
[3] In 2000, Chile registered a union density of 14,8% while in 2016 this number attaint the 19,6% (Dirección del Trabajo, 2016b)

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a sign of the generational turnover and the reactivation of social protest in the country (Observatorio de Huelgas Laborales, 2018), and 3) unions still play a political role in Chile. Historically, Latin-American unions have been tightly related to left-wing political parties and have actively engaged in the political arena, which has not been the case in the United States (Murillo, 2001). Although Chilean unions' ties with political parties have debilitated in the last two decades as part of the neoliberal turn (Zapata, 2001), unions still addressee a lot of their time to influencing political decisions. In this sense, unions can be vital to developing innovation policies. Second, our study takes into account the impact of unions on the different types of innovation defined by the Oslo Manual in 2007. Most of the studies regarding the impact of unions on innovation have considered R&D expenditures as a measure of firm innovation activity. However, as not all R&D investment leads to innovation, it also has been acknowledged that this input measure cannot correctly represent innovation output. To avoid this and adhere to the definition of innovation, this paper will analyze the effect of unions in the different types of innovation, that is, in 1) innovation process, 2) innovation in marketing, 3) organizational innovation, and 4) product innovation.

The paper is organized as follows. Section 2 presents the literature review and develop competing hypotheses. Section 3 provides an overview of the history and legal frame of unions in Chile. Section 4 describes the sample, variables, and methodology. Section 5 presents the main statistics descriptive, and the results, and Section 6 concludes and discusses the results.

2. Literature Review and Hypotheses Development

Empirical research has not been conclusive regarding the extent nor the direction of the unions' influence on innovation. Existing results have shown opposite results depending on the context and strategy of analysis. Expressly, U.S studies from 2010 onwards mainly agree that unions negatively affect innovation. For instance, Angus, Cozzi, and Furukawa (2016) find that an increase in the bargaining power of wage-oriented unionism leads to a decrease in R&D expenditures in the UK and the US. In the same line, Bradley, Kimb and Tianc, (2017), studying innovation at the firm level, find that three years after the union election, the patent quantity, and quality of the U.S companies significantly decline. However, research focused on other advanced economies has shown more controversial findings. In particular, Chun et al. (2015), comparing labor unionized with non-labor unionized Korean manufacturers, find no significant difference in companies' R&D expenditures. On the contrary, some studies in China demonstrate that unions encourage product innovation and R&D investment (Fang and Ying, 2012; Tong et al., 2018). In the same line, Walsworth (2010), using longitudinal firm-level data, shows that the presence of a union in Canada has a small positive effect on the firm's ability to innovate new products.

Beyond the scope of developed countries, the analysis of the effect of unions on innovation has been minimal, particularly in Latin America. An exception is the work of Rios-Ávila (2017), who examines the relationship between unions and productivity in the manufacturing sector across six Latin-American countries: Argentina, Bolivia, Chile, Mexico, Uruguay, and Panamá. Four proxies of innovation are used as control variables: investment in R&D, foreign company technology, product quality certification, and the introduction of new processes or products. The study finds that there is much heterogeneity across the countries of study. For instance, in Chile, a positive and significant effect of unionization is found on the introduction of new processes or products, while no effect is detected for the other three innovation measures. Similar results are observed for Argentina. On the contrary, a negative influence of unions on innovation is identified in Bolivia.

In line with previous studies that have shown conflicting results and heterogeneity among the countries of study, we are going to develop two competing hypotheses to take into account both positions.

2.1. Unions have a negative effect on innovation.

In general terms, the arguments that have been used to support the adverse effect of the unions on innovation can be organized in two groups: the arguments based on the effect of union on wages, and those pointing the influence of unions on management.

A fundamental part of the unions' work is to negotiate wages with employers in order to improve workers' economic wellbeing. In fact, in Chile, the evidence shows that most of the labor conflicts are motivated by wage negotiations (Observatorio de Huelgas Laborales, 2018). Innovation requires considerable investment, but its effect on companies economic indicators takes place, most of the times, in the medium-long term (Rouvinen, 2002). Therefore, companies can be discouraged from making this investment if they think its resulting benefits can be eventually expropriated by unions (Bradley, Kimb, and Tianc, 2017). Moreover, unions are characterized because they usually modify the distribution of wages and reduce inequality among workers (Sanhueza and Fernandez, 2015). For instance, Verma (2005:427) shows that the presence of a union reduces the likelihood of variable pay plans or individual payment incentives. Therefore, innovative workers can be motivated to migrate to non-union firms where individual economic rewards are more likely (Bradley, Kimb and Tianc, 2017).

Unions can also discourage innovation by limiting the management discretion to make the necessary changes within the company to advance toward this specific goal (Walsworth, 2010). For instance, unions can prevent management from implementing human resources policies that could foster a robust corporate culture to enhance employee motivation and commitment to innovation (Verma, 2005: 430). They also can put barriers to dismiss and intervene in the selection process, which can frustrate the plans of management to renew their staff in order to bolster innovation (Verma, 2005:423). Generally, this argument underlines that the existence of a union challenges the control in the workplace and thus makes more complicated the design, implement and assess the innovation plan. Based on the last arguments, our first hypothesis states:

H1: Unions discourage firms' product, marketing, organizational and, process innovations in Chile.

2.2. Unions have a positive effect on the different types of innovation.
On the opposite side, there are also arguments to sustain the positive effect of unions on innovation. The most popular argument is that unions have a *"shock effect"* on companies forcing or persuading management to adopt more efficient practices that they would have ignored otherwise, and that can improve innovation. This argument is based on the assumption that usually, companies do not have the necessary information or human ability to develop the most effective practices for improving innovation on their own. The fact that unions question management and the existent policies may encourage companies to improve and be more creative in order to maintain or increase firm' profits.

Verma (2005) distinguishes two effects within the *"shock effect."* First, there is the *"pure shock"* when unions produce better efficiency in the areas over which management has exclusive control, by the sole fact of existing or without engaging directly in this improvement. Such changes are initiated by management and respond to the idea that unions raise costs (usually increase employees' wages and thus, the cost of labor) and represent a threat; therefore, there is a need to be more efficient. Indeed, in Chile, studies show that union members enjoy a wage premium close to 20 percent (Landerretche, Lillo, and Puentes, 2013). Therefore, companies can be encouraged to compete based on innovation instead of competing based on a low-cost strategy (Walsworth, 2010; Fang and Ying, 2012). Second, there is a *"voice effect,"* which is directly associated with unions' intervention. Unions can push management to change aspects of the production process that affect workers and propose creative solutions that can ultimately favor innovation. They also can help management in the design and implementation of their innovation plans, facilitating communication with employees, and providing feedback to management. There is empirical evidence that supports the idea that collaboration with unions is key to the success of organizational changes led by management (e.g., Martinez-Jurado, Moyano-Fuentes, Jerez-Gomez, 2014).

Besides the *"shock effect,"* the positive effect of unions on innovation can be explained by the impact of unions' actions over the employees' behavior. Unions' actions favor union members' wages, and this can promote their commitment to innovation (Walsworth, 2010). Since innovation requires time to present any effect, companies need active engagement from employees. In that sense, unions provide workers the necessary guarantees to engage in higher-risk behaviors associated with innovation because they increase employment protection limiting dismissals and promoting seniority-based pay at the workplace (Bradley, Kimb and Tianc, 2017; Walsworth, 2010). Based on the recent arguments, our second hypothesis states:

H2: Unions favor firms' product, marketing, organizational, and process innovations in Chile.

3. Unions in Chile: Background.

Since the direction of the union effect on innovation is probably related to the context of analysis, this section is aimed to describe relevant features in the recent history of the Chilean unions and the labor legal framework.

Latin American unions have been characterized as playing a substantial role in the political arena. Chilean unions are not an exception, although this political influence has weakened during the last four decades. Their alliance with the communist and socialist political parties encouraged Chilean unions to increase mobilizations throughout the XX century and supported the political coalition that won the presidential election in 1970 with the promise of leading the country to a socialist economy. Despite their militancy, unions exerted a steady pressure over authorities to advance in the promised reforms (Angell, 1972).

The 1973 military coup deeply stroke unions. Following a period of prohibition and repression against the foremost union leaders, militaries authorized union activity, but under a completely different institutional framework. A set of reforms known as the Work Plan (Plan Laboral) (1979) adapted labor legislation to the neoliberal prescriptions that were implemented to install a market economy in Chile. Unions' prerogatives were largely restricted. For instance, collective bargaining was limited to the firm level; unions were prohibited from negotiating issues that "restrain or limit the faculty of employers to organize, lead or manage companies"; employers were allowed to replace workers and close workplace during strikes; workers were authorized to negotiate without the intervention of a union through the form of a "negotiation group". The explicit goal of this measure was to promote a decentralized and depoliticized system of employment relations which could guarantee employers enough flexibility to adapt the new macro-economic conditions (Winn, 2004)

The recuperation of democracy in 1990 did not bring the transformations that union leaders expected. Despite the strong relationship between the Central Unitaria de Trabajadores (CUT), the leading national union organization, and the political parties of the "Concertación," the center-left coalition in power from 1990 to 2009, labor regulation was minimally reformed. During the first decade, the CUT engaged with the governments in the promotion of a new national social pact between workers and businesses. As a result, a set of "Frame Agreements" was signed with the Confederation of Production and Commerce. However, apart from the increased minimum wage, scholars agree that these pacts were mostly a demonstration of goodwill (e.g., Sehnbruch, 2013; Frank, 2004). The first two labor reforms (1991 and 2001) did not consent to the core demands of the CUT, which is the extension of the collective bargaining to the branch level, the elimination of strikes' restrictions, and negotiation groups. The reform of 2016 eliminated the authorization of employers to replace workers during strikes, which were celebrated by unions as the first substantial change to the Labor Plan. However, other obligations, such as the creation of minimal services and "workers' adjustments", limited the impact of this measure (Arellano, 2015).

The failure of its initial strategy led the CUT to increase mobilizations after 2000. However, its political power has been relatively weakened by the internal divisions (Frias, 2008; Gutiérrez, 2016) and the overall low union density (Dirección del Trabajo, 2016b). This had not prevented unions from playing an essential role in the big and medium-size companies where unions are present in 65,3% and 20,5% cases, respectively (Dirección del Trabajo, 2016a). Moreover, unions assemble more than 20% of the workforce in economic branches such as transportation, financial intermediation, community services, fishing, mining, social services and health (Dirección del Trabajo, 2016b). In most of these branches, union activity has increased over the last decade (Observatorio de Huelgas Laborales, 2018; Gutiérrez and Gutiérrez, 2017).

4. Sample, Variables, and Methodology

4.1. Sample.

The data that we use to test our hypotheses come from the first and second Longitudinal Survey of Companies in Chile[4] (published in the year 2009 and 2012, respectively). These surveys were jointly conducted by the National Institute of Statistics, the Ministry of Economy and the Microdata Center of the University of Chile. The primary purpose of the survey is to characterize the Chilean companies, to identify the determinants of business development as well as to measure the impact of different variables in the Total Productivity Factor. This survey is addressed to formal companies that develop productive, commercial and service activity, within the territorial limits of the country and whose sales level is higher than 2,56 US$ during 2007 and 23.497,63 US$ during 2009.[5] The surveys were conducted by interviewing face-to-face, to the owners, partners or shareholders, and general managers of the companies. One of the strengths of the survey is its longitudinal condition and the fact that it has been replicated in several years (2009, 2012, 2015 and 2017). However, the design of some questions has varied from year to year, which has limited our period of study. Despite the existence of four surveys, we have to focus on the ones published in 2009 and 2012 since the ones from 2015 and 2017 had different questions regarding innovation and, they do not distinguish among the different types of innovation that we consider in this paper. How we proceeded to match the companies from the different surveys was the following: The 2009 survey presents the data for 10.213 companies while the 2012 survey presents the data for 7.062 companies. Since companies have an anonymous identifier that is maintained over time, we match both surveys using it, and we focus on the companies for which we have data in the two periods: this process reduces the number of companies to 2.667.

3.2. Variables.

3.2.1. Dependent Variables

In an attempt to have a proxy for each of the different innovation types defined by the GII, we selected four questions from the questionnaire of the survey, and we convert this information into four dummy variables. Specifically, we have chosen the following questions from the 2012 survey:

Organizational innovation was proxied based on question F009: *Have you carried out activities linked to the preparation and introduction of substantive improvements or new distribution methods? (linked to the logistics of the company)?* With the resulting information, we created a dummy variable equal to 1 if the answer was yes and equal to 0; otherwise.

Product Innovation was proxied based on question F008: *Has your company made any substantive improvement or created a new product in the goods/services it sells?* With the resulting information, we created a dummy variable equal to 1 if the answer was yes and equal to 0; otherwise.

Process innovation was proxied based on question F007: *Have you purchased machines, equipment and/or software for the introduction of new or significantly improved products or processes?* With the resulting information, we created a dummy variable equal to 1 if the answer was yes and equal to 0, otherwise.

Marketing innovation was proxied based on question F010: *Have you made new marketing methods that involve significant changes in the design or packaging of a product, its positioning, its promotion or its pricing?* With the resulting information, we created a dummy variable equal to 1 if the answer was yes and equal to 0; otherwise.

We considered that the resulting information from those questions is comparable with the one from the year 2009, question number 68: *In 2007, did your company introduce innovations? Answer in column 68.1 specifying the type of innovation: product, services, process, organizational and/or marketing.* However, as this survey distinguishes between five different types of innovation, in order to capture the same information, we proceed to sum the product and the service innovation and create a dummy equal to 1 if the company innovate in product and/or in service, equal to 0 otherwise.

Since the objective of the paper is to analyze if the presence of unions favors or deter innovation and the effect in innovation is no immediate (Rouvinen, 2002), our dependent variables were measured in 2012 while our main independent variables were measured in 2009. However, because firms' current innovation (2012) could also be strongly affected by previous innovation activities (2009), since it establishes the propensity to innovate of a company (Geldes et al., 2016), we control for the existence of innovation practices in which companies have engaged in the previous period.

3.2.2. Independent variables

To measure the presence and strength of unions, we selected question number 92: *How many unions exist in your company?* and question 92.1: *What was the percentage of affiliation?* from the 2009 Survey. Based on the answers, the following variables were constructed:

[4] In particular, we used the ELE and ELE2 available at https://www.economia.gob.cl/category/estudios-encuestas/encuestas-y-bases-de-datos/encuesta-longitudinal-de-empresas-ele

[5] The conversion from UF to chilean pesos was done taken into account the UF value of march 2007 (18.383,35 chilean pesos) and the UF value of march 2009 (21.067,76 chilean pesos). After that, we used the exchange rate chilean peso - dollar of 8th october 2019.

1. Union_Existence: Dummy variable that is equal to 1 if there is at least one union in the company, zero otherwise.

2. Union density: Percentage of unionization in each company (from 0 to 100).

3. Union density levels: Dummy variable that distinguishes among the following different levels of union density. In order to analyze if the effect of unions is linear or not in innovation, we construct the same measure as Walsworth (2010), where Union Density None is our base category. Explicitly, we distinguish between the following levels of union density:

- Union Density None: Dummy variable equal to 1 if the percentage of unionization is equal to zero, 0 otherwise.
- Union Density low: Dummy variable equal to 1 if the percentage of unionization is >0 % and 20%, equal to 0 otherwise.
- Union Density moderately low: Dummy variable equal to 1 if the percentage of unionization is >20 and 40%, equal to 0 otherwise.
- Union density medium: Dummy variable equal to 1 if the percentage of unionization is >40% and 60%, equal to 0 otherwise.
- Union density high: Dummy variable equal to 1 if the percentage of unionization is > 60%, equal to 0 otherwise.

3.3.3. Control Variables

Previous innovations: To control from previous innovation activities, we used the innovation dummies in the year 2009. These dummies are defined equal to 1 if the company has introduced this type of innovation, 0 if not. Since the propensity to innovate has been proved to be affect positively to the innovative performance (Geldes et al., 2017), we expect the introduction of innovative practices in the previous period to have a positive effect on the actual period.

Size: We control for company size using the logarithm of the number of employees per company. Based on Avermaete et al. (2003) and Maffini Gomes et al., (2009) we expect the company size to influence innovation.

Age: company age is measured as the difference between the year in which the company was founded and 2009. Based on Avermaete et al. (2003) we expect company age to present an effect on innovation.

Research and Development: Dummy variable equal to one if the firm invested in this period in research and development, and equal to zero otherwise. Following Geldes et al., (2017), we expect this variable to have a positive effect on innovation.

Subcontracting: Dummy variable equal to one if the company subcontracted at least any service in the period, equal to zero otherwise. Based on Beladi. and Mukherjee (2017), we expect this variable to have an effect on innovation.

CEO education: dummy variable equal to one if the CEO possess university education, zero otherwise. Based on Mo-Ahn et al. (2017), we expect CEO education to influence positively on the engagement of innovation practices.

Sector dummies: we add ten dummy sector variables to control for the fact that certain sectors are more prone to have high rates of innovation than others. The different dummies correspond to the following sectors: Mining, Manufacturing, Energy, Construction, Commerce, Hotels / Restaurants, Transportation, Real Estate, Finance, and Others. As the base category, we used the mining sector. Following Cefis and Orsenigo (2001), we expect that innovation to be affected by the different economic sectors.

3.3. Methodology

Since our objective is to evaluate the effect of the existence of unions and union density on the different types of innovation and they are binary variables, we use the following logit model:

$$\Pr(Innovation^{*}12|X_i) = \beta_0 + \beta_1 IV_{union} + \beta_2 Innovation^{*}09 + \beta_3 size + \beta_4 age + \beta_5 RD + \beta_6 subc + \beta_7 CEOeduc + \beta_8 Sector + u_t$$

Where:

- *Innovation**12 = Innov.in production,organization,marketing,and process in 2012.

- IV_{union} = union_existence, union density and union density levels (union_low, union_moderately, union_medium and union_high).

- *Innovation**09 =
- Innov.in production,organization,marketing and process in 2009.

- *Sector* = Sector dummies.

4. Descriptive Statistics and Results

4.1. Descriptive Statistics

Table 1 presents the descriptive statistics of all the variables used in the regression. Regarding innovation variables, we can observe significant differences between the percentage of companies that perform different innovations and a growing trend in each one. Regarding the union variables, we can observe that just 15.3% of the companies have a union.

Table 1: Descriptive Statistics

Dichotomous Variables – Descriptive Statistics					
VARIABLES	N	YES	NO	min	max
Process Innov.12	1,539	70%	30%	0	1
Product Innov.12	1,583	41.3%	58.7%	0	1
Organiz. Innov.12	1,570	23.9%	76.1%	0	1
Marketing Innov.12	1,568	21.6%	78.4%	0	1
Process Innov.09	2,667	26.7%	73.3%	0	1
Product Innov.09	2,667	22.8%	77.2%	0	1
Organiz. Innov.09	2,667	21.9%	78.1%	0	1
Marketing Innov.09	2,667	14.1%	85.9%	0	1
Union Variables					
Union Existence	2,667	15.3%	84.7%	0	1
Union density_none	2,667	84.7%	15.3%	0	1
Union density_low	2,667	2.81%	97.2%	0	1
Union density_modlow	2,667	3.15%	96.8%	0	1
Union density_medium	2,667	3.67%	96.3%	0	1
Union density_high	2,667	5.55%	94.5%	0	1
Firms Characteristics					
R&D	2,667	49.9%	50.1%	0	1
Subcontracting	2,667	18.8%	81.2%	0	1
CEO education	2,667	61,1%	38,9%	0	1
Quantitative Variables – Descriptive Statistics					
VARIABLES	N	mean	Std.	min	max
Size	2,667	212.1	841.56	0	18,357
Union density	2,667	7.605	20.908	0	100
Age	2,667	15.29	15.046	0	154

Table 2 shows the percentage of unions and union density distinguishing among the different sectors in the sample. In this table, we can perceive many differences among sectors.

Table 2: Descriptive Statistics by Sector

Sector Dummies - Statistics			
Variables	**# Firms**	**Union Existence (%)**	**Unionization**
Agriculture	158	9.50%	3.31%
Mining	130	20%	12.89%
Manufacture	357	29.13%	16.32%
Energy	78	48.72%	31.26%
Construction	261	7.66%	3.49%
Commerce	613	8.32%	3.55%
Hotels/Restaurants	270	7.78%	2.80%
Transportation	271	16.97%	8.93%
Real Estate	284	11.27%	4.35%
Finance	100	20%	7.11%
Others	145	23.35%	11.09%
Total	2,667	Mean= 18.43%	Mean=7.60%

Table 3 shows the percentage of companies that introduce the different types of innovations when they have unions vs. if they do not have them. As we can observe, for all the cases, the percentage of companies that introduce innovations is always 10% higher when there are unions. Also, from this table, we can observe that, independently of the presence of unions, the percentage of companies that introduce the different innovation is increasing from the year 2009 to 2012 (except for the case of organizational innovation when there are unions).

Table 3: Descriptive Statistics by the existence of Unions vs the non-existence.

Union existence and Innovations		
Variables	**% Innovation if Union_existence = 1**	**% Innovation if Union_existence = 0**
Product Innov.12	49.25%	39.20%
Process Innov.12	77.64%	67.72%
Organiz. Innov.12	33.83%	21.20%
Marketing Innov.12	27.11%	20.06%
Product Innov.09	34.64%	20.66%
Process Innov.09	51.60 %	22.26%
Organiz. Innov.09	39.80%	18.67%
Marketing Innov.09	25.80%	11.95%

In Table 4, we observe the Pearson correlation among the variables of the study. As we can see, there are several variables with a positive and significant correlation. However, the ones that present a higher correlation (as is the case between the correlation between Union Existence and Union density: 0.857 or between Union density and Union density High: 0.83%) are not together in the regression because they are alternative IV. We do not think the other ones can imply a problem for the analysis.

Table 4: Matrix of Pearson Correlations

Matrix of Correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
(1) Process Innov.12	1.000																			
(2) Product Innov.12	0.206*	1.000																		
(3) Organiz Innov.12	0.110*	0.293*	1.000																	
(4) Market Innov.12	0.023	0.298*	0.405*	1.000																
(5) Product Innov.09	0.046	0.187*	0.166*	0.171*	1.000															
(6) Process Innov.09	0.093*	0.142*	0.114*	0.065	0.415*	1.000														
(7) Organiz Innov.09	0.051	0.119*	0.119*	0.053	0.361*	0.577*	1.000													
(8) Market Innov.09	0.031	0.142*	0.185*	0.160*	0.444*	0.397*	0.469*	1.000												
(9) Union_existence	0.089*	0.083*	0.121*	0.070*	0.120*	0.238*	0.184*	0.143*	1.000											
(10) Union density	0.070*	0.084*	0.110*	0.051	0.098*	0.211*	0.167*	0.116*	0.857*	1.000										
(11) UDensity_none	-0.089*	-0.083*	-0.121*	-0.070*	-0.120*	-0.238*	-0.184*	-0.143*	-1.000	-0.857*	1.000									
(12) UDensity_low	0.054	0.016	0.032	-0.001	0.024	0.101*	0.050*	0.045	0.395*	0.012	-0.395*	1.000								
(13) UDensity_molow	0.030	0.014	-0.007	0.048	0.066*	0.071*	0.050	0.063*	0.425*	0.212*	-0.425*	-0.030	1.000							
(14) UDensity_med	0.023	0.055	0.133*	0.073*	0.079*	0.112*	0.123*	0.093*	0.460*	0.414*	-0.460*	-0.033	-0.035	1.000						
(15) UDensity_high	0.051	0.058	0.053	0.003	0.052*	0.153*	0.105*	0.057*	0.571*	0.831*	-0.571*	-0.041	-0.044	-0.047	1.000					
(16) Size	0.117*	0.109*	0.190*	0.105*	0.216*	0.368*	0.313*	0.229*	0.551*	0.468*	-0.551*	0.215*	0.238*	0.235*	0.318*	1.000				
(17) Age	0.067*	0.100*	0.127*	0.048	0.089*	0.123*	0.087*	0.111*	0.252*	0.228*	-0.252*	0.065*	0.099*	0.148*	0.143*	0.242*	1.000			
(18) R&D	-0.121*	-0.075*	-0.101*	-0.001	-0.103*	-0.202*	-0.152*	-0.124*	-0.238*	-0.200*	0.238*	-0.112*	-0.103*	-0.083*	-0.144*	-0.387*	-0.114*	1.000		
(19) Subcontracting	0.066*	0.084*	0.109*	0.076*	0.125*	0.281*	0.216*	0.147*	0.350*	0.292*	-0.350*	0.101*	0.182*	0.176*	0.181*	0.468*	0.160*	-0.243*	1.000	
(20) CEO edu	0.010	0.106*	0.104*	0.068*	0.140*	0.231*	0.195*	0.114*	0.233*	0.221*	-0.233*	0.049	0.100*	0.123*	0.153*	0.413*	0.084*	-0.184*	0.281*	1.000

* shows significance at the .01 level

4.2. Results

Our estimates of the determinants of innovation are presented in Table 5 (union existence as the independent variable), Table 6 (union density as the independent variable) and Table 7 (union density levels as independent variables). In each table, we can observe the regressions of the four types of innovations, where model 1 present the regression with the control variables and model 2 adds to the existing regression of the independent variable. In Table 5, the coefficient of union existence is negative and no significant for every type of innovation. In Table 6, the coefficient of union density is negative for the product, marketing, and process innovation but not significant. The coefficient of organizational innovation is positive but also no significant. Therefore, neither the results of table 5 nor the ones in table 6 support any of our hypotheses.

Table 5. Logit - Union Existence

	Product Innovation		Organization Innovation		Marketing Innovation		Process Innovation	
VARIABLES	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
Union Existence		-0.131		-0.117		-0.0435		-0.0549
		(0.171)		(0.183)		(0.193)		(0.188)
Product Innov.09	0.408***	0.406***	0.353**	0.350**	0.461***	0.461***	0.0666	0.0651
	(0.137)	(0.137)	(0.157)	(0.157)	(0.163)	(0.163)	(0.153)	(0.153)
Process Innov.09	0.200	0.201	-0.0531	-0.0511	-0.100	-0.100	0.307*	0.308*
	(0.144)	(0.144)	(0.172)	(0.172)	(0.174)	(0.174)	(0.160)	(0.160)
Market. Innov.09	0.182	0.180	0.461**	0.457**	0.550***	0.548***	-0.0788	-0.0799
	(0.166)	(0.165)	(0.182)	(0.181)	(0.184)	(0.184)	(0.180)	(0.180)
Organiz. Innov.09	0.106	0.104	0.0505	0.0487	-0.163	-0.164	-0.0312	-0.0320
	(0.158)	(0.158)	(0.188)	(0.188)	(0.193)	(0.193)	(0.168)	(0.168)
Size	0.0171	0.0310	0.167***	0.181***	0.108**	0.113**	0.101**	0.107**
	(0.0355)	(0.0396)	(0.0397)	(0.0455)	(0.0425)	(0.0482)	(0.0398)	(0.0436)
Age	0.00371	0.00400	0.00397	0.00422	-0.00437	-0.00427	0.00232	0.00244
	(0.00337)	(0.00339)	(0.00388)	(0.00389)	(0.00439)	(0.00440)	(0.00407)	(0.00408)
R&D	-0.0995	-0.0989	-0.107	-0.106	0.245*	0.246*	-0.341***	-0.341***
	(0.121)	(0.121)	(0.142)	(0.142)	(0.147)	(0.147)	(0.126)	(0.126)
Subcontracting	0.147	0.161	0.126	0.136	0.367**	0.372**	0.0208	0.0264
	(0.143)	(0.144)	(0.155)	(0.157)	(0.166)	(0.167)	(0.157)	(0.159)
CEO_edu	0.352***	0.352***	0.264	0.265	0.268	0.268	-0.255*	-0.255*
	(0.135)	(0.135)	(0.163)	(0.163)	(0.165)	(0.165)	(0.145)	(0.145)
Sector Dummies	YES	YES	YES	YES	YES	YES	YES	-0.440
Constant	-1.169***	-1.190***	-2.697***	-2.719***	-2.652***	-2.661***	1.223***	1.216***
	(0.304)	(0.306)	(0.404)	(0.407)	(0.429)	(0.432)	(0.356)	(0.357)
Observations	1,489	1,489	1,481	1,481	1,476	1,476	1,448	1,448
Pseudo R-squared	0.0677	0.0680	0.0869	0.0871	0.0916	0.0917	0.0373	0.0374

Table 6. Logit – Union Density

	Product Innovation		Organization Innovation		Marketing Innovation		Process Innovation	
VARIABLES	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
Union Density		-0.000126		0.000157		-0.000382		-0.00227
		(0.00278)		(0.00292)		(0.00313)		(0.00309)
Product Innov.09	0.408***	0.408***	0.353**	0.353**	0.461***	0.461***	0.0666	0.0641
	(0.137)	(0.137)	(0.157)	(0.157)	(0.163)	(0.163)	(0.153)	(0.153)
Process Innov.09	0.200	0.200	-0.0531	-0.0533	-0.100	-0.100	0.307*	0.306*
	(0.144)	(0.144)	(0.172)	(0.172)	(0.174)	(0.174)	(0.160)	(0.160)
Market. Innov. 09	0.182	0.182	0.461**	0.462**	0.550***	0.549***	-0.0788	-0.0829
	(0.166)	(0.166)	(0.182)	(0.182)	(0.184)	(0.184)	(0.180)	(0.180)
Organiz. Innov.09	0.106	0.106	0.0505	0.0504	-0.163	-0.163	-0.0312	-0.0293
	(0.158)	(0.158)	(0.188)	(0.188)	(0.193)	(0.193)	(0.168)	(0.168)
Size	0.0171	0.0177	0.167***	0.166***	0.108**	0.110**	0.101**	0.112***
	(0.0355)	(0.0380)	(0.0397)	(0.0433)	(0.0425)	(0.0456)	(0.0398)	(0.0425)
Age	0.00371	0.00373	0.00397	0.00395	-0.00437	-0.00431	0.00232	0.00260
	(0.00337)	(0.00339)	(0.00388)	(0.00389)	(0.00439)	(0.00438)	(0.00407)	(0.00406)
R&D	-0.0995	-0.0994	-0.107	-0.107	0.245*	0.246*	-0.341***	-0.341***
	(0.121)	(0.121)	(0.142)	(0.142)	(0.147)	(0.147)	(0.126)	(0.126)
Subcontracting	0.147	0.148	0.126	0.125	0.367**	0.368**	0.0208	0.0284
	(0.143)	(0.143)	(0.155)	(0.156)	(0.166)	(0.166)	(0.157)	(0.157)
CEO_edu	0.352***	0.352***	0.264	0.263	0.268	0.269	-0.255*	-0.252*
Sector Dummies	YES	YES	YES	YES	YES	YES	YES	-0.454
	(0.349)	(0.349)	(0.487)	(0.487)	(0.479)	(0.479)	(0.405)	(0.404)
Constant	-1.169***	-1.170***	-2.697***	-2.697***	-2.652***	-2.654***	1.223***	1.218***
	(0.304)	(0.304)	(0.404)	(0.405)	(0.429)	(0.430)	(0.356)	(0.356)
Observations	1,489	1,489	1,481	1,481	1,476	1,476	1,448	1,448
Pseudo R-squared	0.0677	0.0677	0.0869	0.0869	0.0916	0.0916	0.0373	0.0376

Table 7. Logit - Union Density Level

	Product Innovation		Organization Innovation		Marketing Innovation		Process Innovation	
VARIABLES	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
UDensity_low		-0.0128		-0.242		-0.663*		0.229
		(0.320)		(0.322)		(0.389)		(0.379)
UDensity_modlow		-0.387		-0.904***		0.00179		-0.192
		(0.279)		(0.324)		(0.307)		(0.311)
UDensity_medium		-0.0355		0.524*		0.209		-0.265
		(0.272)		(0.275)		(0.288)		(0.301)
UDensity_high		-0.00393		-0.180		-0.285		-0.144
		(0.238)		(0.259)		(0.283)		(0.269)
Product Innov.09	0.408***	0.413***	0.353**	0.369**	0.461***	0.453***	0.0666	0.0692
	(0.137)	(0.137)	(0.157)	(0.157)	(0.163)	(0.163)	(0.153)	(0.153)
Process Innov.09	0.200	0.191	-0.0531	-0.0566	-0.100	-0.0797	0.307*	0.297*
	(0.144)	(0.145)	(0.172)	(0.171)	(0.174)	(0.174)	(0.160)	(0.160)
Market. Innov.09	0.182	0.181	0.461**	0.476***	0.550***	0.555***	-0.0788	-0.0868
	(0.166)	(0.166)	(0.182)	(0.182)	(0.184)	(0.184)	(0.180)	(0.180)
Organiz. Innov.09	0.106	0.101	0.0505	0.0176	-0.163	-0.182	-0.0312	-0.0245
	(0.158)	(0.159)	(0.188)	(0.187)	(0.193)	(0.192)	(0.168)	(0.168)
Size	0.0171	0.0271	0.167***	0.191***	0.108**	0.127***	0.101**	0.112***
	(0.0355)	(0.0392)	(0.0397)	(0.0458)	(0.0425)	(0.0484)	(0.0398)	(0.0432)
Age	0.00371	0.00388	0.00397	0.00384	-0.00437	-0.00445	0.00232	0.00271
	(0.00337)	(0.00339)	(0.00388)	(0.00412)	(0.00439)	(0.00445)	(0.00407)	(0.00405)
R&D	-0.0995	-0.0988	-0.107	-0.111	0.245*	0.237	-0.341***	-0.337***
	(0.121)	(0.120)	(0.142)	(0.142)	(0.147)	(0.147)	(0.126)	(0.127)
Subcontracting	0.147	0.171	0.126	0.146	0.367**	0.363**	0.0208	0.0427
	(0.143)	(0.144)	(0.155)	(0.157)	(0.166)	(0.168)	(0.157)	(0.159)
CEO edu	0.352***	0.350***	0.264	0.254	0.268	0.267	-0.255*	-0.249*
	(0.135)	(0.136)	(0.163)	(0.164)	(0.165)	(0.165)	(0.145)	(0.145)
Sector dummies	YES	YES	YES	YES	YES	YES	YES	(0.353)
Constant	-1.169***	-1.199***	-2.697***	-2.794***	-2.652***	-2.676***	1.223***	-0.639
	(0.304)	(0.305)	(0.404)	(0.425)	(0.429)	(0.438)	(0.356)	(0.444)
								-0.865**
Observations	1,489	1,489	1,481	1,481	1,476	1,476	1,448	(0.361)
Pseudo R-squared	0.0387	0.0687	0.0387	0.0960	0.0387	0.0948	0.0387	-0.827**
								(0.337)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

However, table 7 shows more precise results. In this table, union density is segmented into five groups. The dummy variable identifying companies with null union density acts as the reference group for the remaining four union density level variables. As is observed, for the product, and process innovation the coefficients for every union density level are no significant. However, for organizational innovation, the coefficient for union density moderately low is negative and significant at the 0.01 level while the coefficient for union density medium is positive and significant at the 0.1 level. In other words, compared to companies with no union presence, a moderately low level of union density (> 20% - 40%) restricts a company's capacity to innovate in organizational aspects, whereas the medium level of union density (> 40% - 60%)) promote this type of innovation. The coefficients for the other two extreme union density levels (low and high union density) are not statistically significant for this type of innovation. For marketing innovation, a significant negative effect at the 0.01 level is observed for companies with low union density (20). Meanwhile, companies with higher levels of union density do not show significant results. All these results are supported using the Probit model[6]

5. Conclusion and Discussion

The primary objective of this paper was to analyze the effect of unions on innovation in the Chilean context. Our results do not support completely any of the two competing hypotheses, instead they suggest both are acceptable because the direction and significance of union effect depend on the type of innovation and the union density level.

Two interesting questions arise from these findings and demand further research in the field. First, why is the union' effect significant on the organizational and marketing innovations and is not on the product and the process innovations? The particularities of the Chilean context could help to understand this puzzle. As it was mentioned in the background section, the legislation radically limits the scope of negotiation. In practice, collective bargaining is restrained from wasting adjustment, working time, workers' benefits and other superficial aspects of the labor process (Dirección del Trabajo, 2016a). Moreover, chilean union leaders rarely count with basic business or management training, therefore they have difficulties to negotiate in equal conditions with managers complicate aspects of production. In consequence, any union intervention in favor or against innovation will probably refer to organizational aspects.

On the other hand, the adverse effect of unions on marketing innovation may be explained by the unions' effect on wages. In general terms, companies that feel threatened and that face any level of uncertainty, tend to reduce investments in intangible assets, such as marketing, because their effects are not immediate and a priori do not affect the company production (Stein, 2005). In the same line, it could be that Chilean companies may be motivated to cut off or reduce the investment in marketing innovation when they fear unions can eventually expropriate the fruit of this investment. No doubt, it is easier and less costly for companies to intervene in this area to compensate unions' effect on wage compared with reducing the process or product innovation that can put at risk their competitive advantage. Further research should explain why this effect became statistically insignificant for companies with more than 20% of union density.

The second question refers to the differences that were found between the coefficients of the four union density levels. On the one hand, the effect of union on organizational innovation was not significant in companies with the lowest union density. This may be explained because unions in these cases are too weak to force management to modify its practices, either to stop an innovation plan or to promote one. The effect on organizational innovation would become visible when unions count with the support of a more relevant part of the employees and thus when they can challenge management. On the other hand, the effect on the organizational innovation revealed to be negative when union density is between 20% and 40%, positive when is between 40% and 60%, and negative but not significant when is higher than 60%. This suggests that organizational innovation does not respond linearly to union strength. For instance, powerful middle unions may be more motivated to collaborate with management in the implementation of an innovation plan than moderately low powerful unions because the first have probably satisfied more basic needs and have more chances to turn this plan in favor of workers. Instead, strongest unions could be interested in pursuing more radical changes at the workplace that are not necessarily favorable to management's innovation's plans because they have the resources to do so. In other words, whether unions and management collaborate for fostering innovation depend on multiple factors, union density could be just one of them. Further research is needed to identify the other factors at stake. A key aspect to consider in this research should be the power of unions in different economic branches. Regardless of the union density, chilean unions in economic branches such mining, that are strategic for the country, have more chances to force management to negotiate and, thus, to affect innovation.

Finally, we consider essential to point out the implication of our findings to the GII. Although their role in innovative activities depends on multiple factors, unions are an important element of the national economy in countries with high union density or where unions play a political role. This is the case of many Latin America nations. Our findings confirm that, under certain conditions, unions can generate inefficiency inside the organization and divert companies from innovating, but they can also be a key ally for management to promote such initiatives. In this sense, in our opinion, the GII should consider this aspect in its analysis. We are not suggesting that the GII should encourage countries to promote unions for increasing firms' competitiveness, but that it should consider the existence of these organizations as a relevant parameter in the design and implementation of innovation policies.

[6] For further information regarding the tables, please contact the corresponding author.

This paper presents two main limitations: First, our sample is not representative; therefore, our results cannot be generalized to the whole population. Second, our study considers just two periods, limiting the use of econometric models that can capture better the specificities of the data. Further research should be focused on capturing better and more detailed data to complement the presented results.

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The Impact of Cooperation on Business Innovation in Developing Countries: Evidence from Chile in Latin America

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Abstract: There is abundant empirical evidence supporting the relationship between cooperation and innovative entrepreneurial activity, but the conversation continues to be limited to the context of developing countries. This study contributes to the academic debate on this topic with an empirical evaluation of the effect of cooperation networks on innovation, using Chile in Latin America as a case study. Furthermore, while previous studies mainly refer to technological innovations in a particular industrial sector, in this paper we will build an innovation measurement system that incorporates both technological and non-technological activities among diverse industrial sectors. Upon applying cross-sectional data from a national survey on innovation in a developing firm from two different years to a zero-inflated negative binomial regression, we found that a business that reports on cooperation conducts more innovative activities per year compared to one that does not. The type of agent that a business cooperates with is also relevant in this context; other businesses, clients, and consultants showed stronger and more stable results than other types of agents. This evidence is relevant as it presents new information about the importance of the type of agent that a business cooperates with in the context of developing countries.

Keywords: Business Innovation; Cooperation; Developing Country

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Highlights:

- Previous studies mainly refer to technological innovations in a particular industrial sector and in the context of developed countries.
- In this work, we built an innovation measurement system that incorporates both technological and non-technological activities among diverse industrial sectors.
- The type of agent that a business cooperates with is relevant in the context of a developing country. Particularly, cooperating with other businesses, clients, and consultants showed stronger and more stable results compared to cooperating with other types of agents.
- We believe that our results contribute to the discussion about innovation and cooperation, given that we found differences in how businesses address cooperation when the context they are in is different.

1. Introduction

While empirical literature positively correlates cooperation with innovation (Fagerberg, Mowery, & Nelson, 2006b), the evidence is focused mainly on technological innovations (invention patents), and only in the context of developed countries. This inhibits an understanding of the role of cooperation in less developed countries and hides the crucial role that alternative innovations, like non-technological ones, can play. Pippel (2004) highlights this situation, indicating that Research and Development (R&D) literature almost exclusively centers on technological innovations, ignoring the fact that countries with a mid-to-low level of human capital might prefer innovations that are organizational or not directly related to technology. This leads us to ask, is the relationship between cooperation and innovation different in developing markets? Furthermore, is technological innovation only a partial vision of the concept of current innovation?

There is literature in favor of the idea that developed and developing countries present differences in innovation processes. K. Zhu, Kraemer, & Xu (2006) studied the process of firms adopting new technologies, maintaining that the preparation of technology, its integration, firm size, global reach, management obstacles, competition intensity, and regulatory environment all influence the assimilation of e-commerce within firms. They used data from 1,857 firms from 10 countries to test their conceptual model. Among their main results, the economic environments that configure innovation assimilation stand out. In particular, the regulatory environment plays a more important role in developing countries than in developed ones. On the other hand, while technology is the most important factor in facilitating assimilation in developing countries, technological integration has proven to be stronger in developed countries.

Technology is only a partial look at innovation, but it sets a valuable precedent that allows us to measure and compare contexts. During the 2007-2012 period, Chile obtained 12 annual patent families on average. The total measure for the same period in the OECD rises to 48,242 patent families (Fuentes Solís & Ferrada Rubio, 2016). The aforementioned demonstrates both the enormous technological difference between developed and developing countries, and that Chile, given the information available, proves to be a particularly interesting case study. Beyond the country context and without downplaying the significance of technology, the importance of non-technological

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innovations is increasingly gaining momentum. H. Zhu, Zhang, & Lin (2016) examined the case of China's mobile phone manufacturing industry between 1998 and 2008 and provided evidence that in the context of emerging markets, innovations in business models help to increase the market shares of firms that have more limited resources. The work of Heredia Pérez, Geldes, Kunc, & Flores (2019) also contributes to a broader look at innovation, as its analysis considers both technological and non-technological innovations.

Pippel (2014) studied the impact of cooperation in R&D on the performance of firms' non-technological innovations. It distinguishes between seven different types of cooperation partners. The study takes data from German firms and uses a logit for the econometric analysis. The work shows that R&D cooperation increases the probability that a firm will introduce non-technological innovations. In addition, R&D cooperation with providers, consultants, and other firms within the same group of firms and universities have a positive and significant impact on the performance of organizational and marketing innovation. This study presents remarkable empirical evidence focused on non-technological innovations in a developed country. Wadho & Chaudhry (2018) studied innovation in a developing country by analyzing clothing and textile manufacturers in Pakistan. While the article does not center its focus on cooperation, it presents interesting evidence on factors that drive businesses to innovate in the context of a developing country.

The existing literature centered on evidence from developed countries and groups three types of links between innovation and cooperation: formal, informal, and multi-part (Fagerberg, Mowery, & Nelson, 2006b). Regarding formal connections, this suggests a positive and significant relationship between the formation of alliances and innovation, a relationship that remains significant across industries and economic sectors (Fagerberg, Mowery, & Nelson, 2006b). The majority of these studies are centered on high-technology industries, and generally use patents as measures of innovation. Among the diverse arguments that support the relationship between cooperation and innovation we find: the density of the bonds that facilitate the exchange of knowledge, mutual learning, and rapid response capabilities (Dyer, 1996; Dyer & Nobeoka, 2000). Various studies also argue that the exchange of complex information is reinforced by deep bonds, which suggests that informal bonds also have the potential to make a significant contribution to innovation. Powell (1996) maintains that formal relations are preserved primarily in informal relationships. Hippel (1987) studied information exchange between American steel-producing firms, using interviews with plant managers and other engineers with direct knowledge of the manufacturing processes. When social-professional relationships among engineers in rival firms were particularly close, more exclusive information was exchanged. Many of the studies on networks and innovation have examined the bonds where more than two parties interact. (Rosenkpf & Tushman, 1998) highlight the importance of the multi-parties that connect technical professionals among organizations. The work of Friedman & Carmeli (2017) also provides evidence on the importance of networks or connections at the time of innovation. They presented data compiled from 149 small businesses and indicated that the link between strategic decision capacity and innovative behavior was stronger when the relationships between the members were characterized by a high level of connectivity.

Given that we are especially interested in the types of agents that firms choose when innovating, we needed a broader theoretical framework that allowed us to isolate the effect of the types of agents while simultaneously controlling other effects through the relevant dimensions or variable groups that participate in this phenomenon. Some key factors at the time of innovating are the personal characteristics of the owners: age, education, and management style (Fagerberg, Mowery, & Nelson, 2006a). Other authors incorporate characteristics such as size, exports, debt, firm age, legal incorporation, and product diversification (de Mel, McKenzie, & Woodruff, 2009). Along this line, Marsh (2004) highlights seven groups of variables or dimensions that influence the decision to innovate: idea stock, market demand for a new product, technological opportunities, market structure, firm characteristics, appropriability of the new product or process, and the interaction between institutions and institutional factors. While we recognize the relevancy of each one of these groups of variables proposed by the authors, our study cannot consider all of them, mainly due to information limitations. However, the available information allows us to approximate four groups or dimensions of variables: 1) Human capital. The number of workers or employees and the proportion of professionals and technicians. 2) Market. The industry in which each firm participates. 3) Size. Sales or income. 4) Cooperation networks. Cooperative ties with diverse agents or organizations, such as: firms, clients, providers, competitors, consultants, universities, and research institutes.

There are three points that highlight the novelty of this work. The first is in regards to the discussion in the existing literature. In general, there is no doubt that cooperation improves the amount of innovative activity in firms, but the empirical evidence of this is centered on data from developed countries – as a result, the argument will not be valid for developing countries. Second, our data incorporates a broader measurement of innovation, as we incorporate technological and non-technological data for various industrial sectors. Third, the econometric technique we used recognizes the problem of zero abundance and allows us to estimate a first innovative activity, which is a change from 0 to 1, as well as an increase in innovative activity, which is a change from 1 to greater than 1. Our hypothesis posits that cooperation plays a relevant role in innovation in the context of a developing country, but with certain differences with respect to developed countries.

2. Data

The database used combines two versions of the National Innovation Survey of Chile (ENI- Spanish acronym, 2010 and 2012). This survey is directed by the Chilean Ministry of Economy, Development, and Tourism and collected by the National Statistics Institute (INE- Spanish acronym). The target population of both studies was firms that declared taxes during 2009 and 2011, respectively. The database was comprised of 6,548 firms. The independent variables of the model are represented by a human capital vector (number of employees and percentage of professionals and technicians), a variable that defines a characteristic of the market the firm participates in (industrial sector), a variable that represents the size of the firm (measured in level of sales), and variables of networks (cooperation). The question regarding cooperation in the survey seeks an explicit response that implies the declaration of a firm regarding some type of formal link with another institution, whether it be with clients, providers, and/or universities.

The questions that each firm responded to regarding innovation are presented in the following table. All answers to questions about innovation are binary (yes/no).

Type of Innovation	Questions
Product	1. Was the product innovation new for the market? 2. Was the product innovation new for your firm?
Process	1. Did your firm introduce a new or significantly improved method for manufacturing or producing goods or services? 2. Did your firm introduce a new or significantly improved method of logistics, delivery or distribution of supplies, goods, or services? 3. Did your firm introduce a new or significantly improved support activity for its processes, such as a maintenance system or purchase transactions, accounting, or IT?
Marketing	1. Did your firm introduce significant changes in the design, packaging, or boxing of products (goods and services)? 2. Did your firm introduce new means or techniques for promoting the product? 3. Did your firm introduce new methods for the distribution channels of the product? 4. Did your firm introduce new methods of pricing of goods or services?
Organizational methods	1. Did your firm introduce new negotiation practices for the organization of processes? 2. Did your firm introduce new methods for organizing responsibilities and decision-making? 3. Did your firm introduce new methods for organizing external relationships with other firms or public institutions?

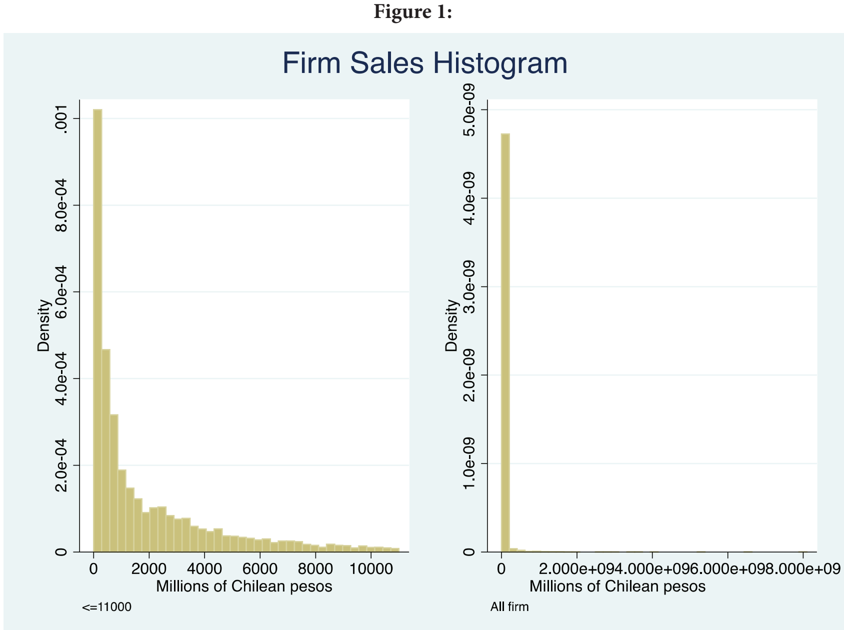
Source: Own elaboration using ENI survey data

The survey questions that each firm responded to regarding cooperation are: Do you conduct cooperation activities with other businesses or institutions in any of the innovative activities conducted? Are providers a source of information for you? Are clients a source of information for you? Are universities a source of information for you? … There are similar questions for other possible cooperative agents.

The first variable is called Cooperation, and the following three are considered variables of cooperation with providers, clients, and universities. All answers are binary (yes/no).

The combination of the two original databases showed 8,267 observations. We decided to restrict the base to ultimately 6,548 observations to improve the sales distribution of firms. We developed a histogram demonstrating how sales distribution changed for firms before and after the restriction. We applied a restriction to the companies' sales rank, sales less than or equal to 11,000 million Chilean pesos. The criterion to apply the restriction was to eliminate data far from a normal distribution (Figure 1).

Figure 1:



Source: Own elaboration

3. Econometric strategy

We used a zero-inflated negative binomial regression (ZINB) to estimate the number of annual innovative activities of firms. The dependent variable is a set of natural numbers where the range of innovative activities moves between 0 (no innovation) and 12 innovative activities.

A ZINB model is a standard econometric approach to contexts where the nature of the dependent variable is the counting of events. That means such a variable is a non-negative integer. The zero-inflated models divide the estimation in two parts; one part estimates the probability to change the event from 0 to 1, which follows a logit or probit model; and a second part, which considers the count (1,2,3,…) assuming a negative-binomial distribution, for the case of a ZINB. This econometric strategy is the best option when a count model has a high proportion of zeros in the outcome variable, and that is the reason for the logit distribution part into the estimation (Cameron & Trivedi, 2013).

Regarding the interpretation of the estimated parameters, it is possible to use the signs of both the count and binary models to interpret the direction of the effect of the independent variable, but the precise estimate requires the estimation of the marginal effects. Given the non-linear specification of our model, the marginal effect of each variable does not correspond to each estimated parameter, so we needed to estimate the marginal effect complementarily. As it is a combined model, the binary part allowed us to estimate the changes of {0,1} innovative activities and the count part allowed us to estimate the innovative activities {2,12}.

The methodology of this article addressed three situations through the proposed model. First, the dependent variable had an excessive number of zeros which skewed its empirical distribution (Greene, 2008; Lambert, 1992). Second, we are interested in the dichotomic decision to innovate or not, as well as the number of innovative activities. Third, the focus of the study is in the effect of cooperation. This variable, given the characteristics of the base used, is dichotomic. The ZINB model allows us to address these three situations.

The advantage of our focus stems from the fact that we can econometrically model the dependent variable as a discrete magnitude, as well as establishing which determinants affect the magnitude of said innovative activity, without losing sight of the effect of cooperation. One limitation is that each innovation activity is built in an additive manner, and as such, its weight is ordinal, meaning that the model assumes that each contributes equally with the same weight. Future studies should attempt to improve the limitations of this focus.

4. Descriptive analysis

In this section, we will present relevant, descriptive statistical evidence, separating the innovative firms from the non-innovative ones. This is a first approximation of the differences between the groups.

Table 2. Innovative and Non-innovative Firms

Variable	Variable Description	Innovative firms (1,979 observations)	Non-innovative firms (4,569 observations)
		Average	Average
Number of innovations	Whole number. Figure declared for one year	3.793	0
Sector	Binary variable by sector		
Fishing		0.019	0.033
Mining		0.005	0.004
Manufacturing		0.263	0.263
Energy		0.018	0.015
Construction		0.078	0.075
Commerce		0.113	0.125
Hotels		0.063	0.059
Transport		0.080	0.092
Finance		0.026	0.044
Development		0.169	0.155
Health		0.063	0.042
Entertainment		0.047	0.043
Cooperation	Binary variable by type of agent		
Other firms		0.048	0.002
Clients		0.054	0.001
Providers		0.063	0.001
Competitors		0.030	0.000
Consultants		0.042	0.001
Universities		0.053	0.002
Research institutions		0.023	0.002
Sales	Annual national sales plus exportations in millions of pesos, two-year average[1]	2,403,416	1,652,119
Employment	Number of employees, two-year average[1]	140,200	83,662
% Professionals and technicians	Percentage of professionals and technicians with respect to the total number of contracted and subcontracted persons[1]	0.390	0.339

Note: [1]The statistic corresponds to an average from two years. This average was constructed based on figures declared by the firms. It is necessary to remember that the base used corresponds to the fusion of two cross-sectional surveys, where it cannot be known if a firm had participated in both surveys. For the 2010 survey (7ma), the firms declared sales numbers for 2009 and 2010. For the 2012 survey (8va), the firms declared sales numbers for 2011 and 2012.
Source: Own elaboration based on the 2010 and 2012 National Survey of Innovation.

In order to demonstrate innovation from a general perspective, Table 2 separates innovative firms and non-innovative firms and incorporates both technological and non-technological types. We found that 30% (1,979/6,548) of firms are innovative and that there are important differences in the averages of almost all variables between both groups. Innovative firms have on average 140,200 employees, of which around 39% are qualified technicians. Annually, these firms have average sales that border 3.5 billion[1] USD. Finally, and of considerable interest to us, 5% of firms that innovate declared that they cooperate with other businesses-clients-universities. 6% of the firms do some type of cooperation with providers, 4% with consultants, 3% with competitors, and 2% with Research Institutions.

It is interesting to notice there is a Pearce-correlation between 38-72% among the innovation types and cooperation types (tables A.1 and A.2 at the appendix). This provides some intuition on how these elements are related.

5. Results

There are three things that must be mentioned before interpreting Table 3. First, as we elaborated in the economic modeling section, the count model allowed us to infer the number of innovative activities, and the inflated model (Probit) made it possible for us to calculate the probability of starting the first innovative activity. Second, we have three groups of variables to analyze: the effects of the industrial sectors, the types of cooperation, and the individual characteristics of the businesses. Third, this is a first interpretation of the data, given that upon reviewing the marginal effects we can better appreciate the magnitudes. The results of the estimations will be interpreted following the three previous points.

Regarding the industrial sectors, seven sectors presented significant effects in the estimation: Manufacturing, Construction, Commerce, Hotels, Transport, Health, and Entertainment. The number of annual innovative activities in these sectors is significantly greater than in others.

Regarding cooperation, three types of agents showed significance: cooperation between firms, clients, and consultants. The cooperation between firms and these types of agents entails a significant rise in annual innovation activities.

The dispersion coefficient *alpha* was used to check if ZINB is the better approach for this analysis, instead of using a Poisson distribution for counting (ZIP). The *alpha*'s confidence interval was [0.52; 0.77], which means it was statistically different from zero (hence, *log(alpha)* is not negative infinity), which means a ZINB model had a better fit than a ZIP.

A probit model was also implemented as a robustness check, where the outcome variable was 1 when the firm performed at least one innovation activity, and zero otherwise. The estimation delivers parameters with very close estimators, in terms of size and signs. Nevertheless, these coefficients are not discussed in this paper. This is due to the fact that the binary nature of the outcome variable hides the effect of the counting, which is the very sense of the phenomenon under scrutiny here.

Table 3: Estimations

	ZINB model				Probit model	
Variables	Count	SD	Inflated	SD		
Fishing	-0.130	(0.185)			-0.302**	(0.145)
Mining	-0.054	(0.326)			0.239	(0.270)
Manufacturing	0.196*	(0.104)			0.143*	(0.085)
Energy	0.022	(0.188)			-0.063	(0.164)
Construction	0.215*	(0.124)			0.138	(0.101)
Commerce	0.212*	(0.116)			0.047	(0.094)
Hotels	0.543***	(0.128)			0.353***	(0.107)
Transport	0.339***	(0.122)			0.123	(0.099)
Finance	-0.110	(0.168)			-0.257*	(0.132)
Development	0.150	(0.109)			0.104	(0.093)
Health	0.394***	(0.129)			0.276**	(0.115)
Entertainment	0.389***	(0.137)			0.265**	(0.113)
Firm cooperation	0.201*	(0.121)			0.423**	(0.192)
Client cooperation	0.447***	(0.123)			0.813***	(0.191)
Provider cooperation	0.169	(0.110)			0.916***	(0.167)
Competitor cooperation	-0.097	(0.142)			0.808***	(0.256)
Consultant cooperation	0.287**	(0.129)			0.447**	(0.205)
University cooperation	0.116	(0.114)			0.580***	(0.173)
Institution cooperation	0.177	(0.153)			0.259	(0.224)
Survey Version	0.190***	(0.045)			0.125***	(0.037)
Sales			-1.4e-4***	(1.5e-5)	6.3e-5***	(7.6e-6)
Employment			-4.8e-4**	(1.8e-4)	7.4e-5*	(4.2e-5)
Technicians and professionals			-0.519***	(0.094)	0.229***	(0.060)
Constant	0.698***	(0.104)	0.988***	(0.059)	-1.224***	(0.083)
Observations	6,548		6,548		6,548	
Log(alpha)	-0.450***	(0.097)				
Voung	9.30***					

** significance at 10%, ** significance at 5%, *** significance at 1%*

[1] $1 USD = $678.06 Chilean pesos. Therefore $4,403,416 million Chilean pesos is equivalent to $3,544,560,000 USD.

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With respect to the variables we are calling individual, sales, the number of workers, and the percentage of professionals and technicians, we found that they push the firms to their first innovative activity. The negative signs only reflect the change from 0 to 1, and upon reviewing the marginal effects, we can more clearly see the magnitude and sign of this estimated parameter.

After controlling for industrial sectors and a group of individual variables, the main results of this section indicated that certain types of cooperation have an effect on a firm's annual innovation activities, and other types of cooperant agents do not. In particular, cooperation with firms, clients, and consultants has a significant effect in this context. Cooperation with providers, competitors, universities, and institutes does not have a significant effect. The significant and positive effect of cooperation with clients, consultants, and firms on the annual innovative activities of the firms stands out in Table 3. Within the context of developing countries, these three types of cooperation seem to be more efficient when innovating.

For an even more thorough analysis, Table 4 shows the estimations of the marginal effects of the ZINB model.

Table 4: Marginal effects of the ZINB estimate

Variables	Marginal Effect	Standard deviation
Fishing	-0.143	(0.204)
Mining	-0.0589	(0.359)
Manufacturing	0.216*	(0.115)
Energy	0.0237	(0.207)
Construction	0.236*	(0.136)
Commerce	0.233*	(0.128)
Hotels	0.598***	(0.142)
Transport	0.373***	(0.136)
Finance	-0.121	(0.185)
Development	0.165	(0.120)
Health	0.433***	(0.142)
Entertainment	0.429***	(0.152)
Firm cooperation	0.222*	(0.133)
Client cooperation	0.492***	(0.136)
Provider cooperation	0.186	(0.121)
Competitor cooperation	-0.107	(0.156)
Consultant cooperation	0.316**	(0.143)
University cooperation	0.127	(0.126)
Institute cooperation	0.194	(0.169)
Survey version (2010/2012)	0.209***	(0.0507)
Sales	9.08e-05***	(9.53e-06)
Employment	0.000314***	(0.000121)
Proportion of professionals to technicians	0.337***	(0.0603)
Observations	6,548	

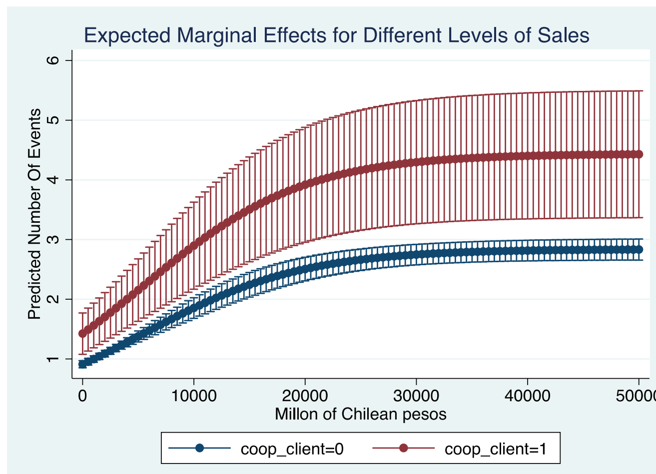
Note:

*** p<0.01, ** p<0.05, * p<0.1

Table 4 shows the positive and significant effect of Manufacturing, Construction, Commerce, Hotels, Transport, Health, and Entertainment. This indicates that firms that participate in these industrial sectors would have greater probabilities of innovating, according to our estimates. In particular, Hotels, Health, and Entertainment are the sectors that present the greatest magnitudes. The more cooperation with firms, clients, and consultants is presented with significant and positive values, the greater the magnitude of cooperation with clients and consultants. This implies that firms that cooperate with clients, consultants, and other firms present greater probabilities of innovating. Regarding the group of individual sales variables, employment, and the percentage of professionals and technicians, we noted a highly significant positive sign. This implies that the size of the firm, measured in sales, number of employees, and the proportion of professionals and technicians, are variables that positively affect the probability of innovation for a firm. The version of the survey is also significant and positive, which helps us control for any temporal effect that may have changed the year the survey was conducted. It should be noted again that we utilized a database that incorporates two other groups of surveys that were taken in different years.

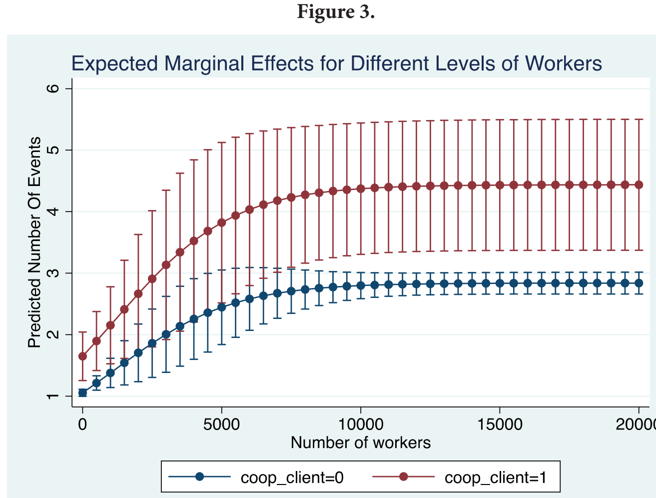
Figure 2 presents an econometric post-estimation analysis. The objective was to analyze the expected marginal effects of the previously calibrated model. Graphics 2 and 3 were created to project the expected innovative activities starting with the evolution of sales and the number of employees when firms cooperate with clients and when they do not.

Figure 2.



Source: Own preparation

Figure 3.



Source: Own elaboration

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Figure 2 demonstrates that when there is no cooperation with clients, the expected innovative activity starts under 1 and advances quite marginally as the size of the firm (measured in sales) grows, arriving at a value under 3 innovative activities per year. When there is cooperation with clients, the initial expected effect starts over 1 activity per year and moves up to more than 4 and less than 5 annual activities as the size of the firm grows. A similar analysis is presented as the number of employees grows (see Graphic 3). The results are similar to those of Graphic 2.

These results show the significance of cooperation, but even more interestingly, they show that its mere existence is not a guarantee of a causal effect. In aggregate terms, a firm that does one innovative activity per year on average without cooperating could experience an increase to 4 annual innovative activities if they incorporated more cooperation activities with clients – thereby quadrupling their possibilities for innovation.

6. Discussion

The most cited studies on the topic of business innovation measure innovation from a technological perspective focused on invention patents. A primary example of this is the work of Jaffe, Trajtenberg, & Henderson (1993), and their study on the geographical locations of new patents compared to the location of patents cited within the United States. The study showed that it is likely that new patents will originate from the United States and from the same state, which highlights the importance of location. The work of Lissoni, Llerena, McKelvey, & Sanditov (2008) also centers its focus on patent creation as a way to measure innovation, providing statistics outlined in a database of academic patents in France, Italy, and Sweden. They showed that the contribution of European universities to national patents does not seem to be significantly less intense than that of its American homologues. The work of Jensen, Wenster, & Buddelmeyer (2008), while also using patents to measure innovation, centered its primary interest on the determining factors of a firm's survival. They demonstrated that, among other factors, innovation influences firm survival. Other studies such as Mansfield (1986), Acs & Audretsch (1988) and Heller (1998) also consider patents as a measurement of innovation. We recognize that these previous studies are an important contribution to knowledge about innovation, but we also believe that looking at innovation solely from the perspective of patents is provides an incomplete perspective on this subject. Our focus when measuring innovation was not on patents, but on a broader and more novel measurement of innovation that incorporates both a technological and non-technological approximation. This measurement of innovation is also recognized by the OECD's literature on innovation (OECD, 2005). Furthermore, we believe that this is a better measurement for understanding innovative activities in the contexts of developing countries.

There are experiences in developed countries using broader measures of innovation, such as the case of De Faria & Schmidt (2012). They studied the cases of Portugal and Germany, analyzing the factors that push private firms to cooperate with partners from other countries in innovation activities, an incorporated non-technological innovation in their innovation measurements. Their work uses the Community Innovation Survey III (CIS), a survey based on the manual of Oslo (OECD, 2005), as a base. This comparison is interesting, as they contrasted a country oriented toward the exportation of high technology, Germany, with a country that is highly dependent on imports and is characterized by a strong tertiary industry, Portugal. Even with these structural differences, the authors demonstarted that both foreign and national cooperation have significant effects on the levels of innovation, delivering new information regarding the relationship between both variables for different economic contexts. The studies of Torres & De la Fuente (2011), van Uden, Knoben, & Vermeulen (2016), and Waheed (2017) used CIS and as such, utilized the directories of the OECD as a base. In particular, Torres & la Fuente (2011) measured the innovations of a group of tourism firms in the city of Pucón, Chile, which provided evidence in the context of a developing country. Using data from 13 countries in Europe, Srholec (2014) analyzed the measure in which national macroeconomic conditions show the propensity of firms to cooperate in innovation nationally and internationally. The results indicated strong differences between the countries on this last point. The firms that operated in countries with less developed research infrastructures have a higher propensity for cooperating with foreign partners. Thus, size and openness of the economy are relevant factors. Geldes, Heredia, Felzensztein, & Mora (2017) conducted a study within the context of a developing country using a broader measure of innovation: they focused on geographical proximity (spatial) to study the determinants of cooperation in the Chilean agro-industry. They modeled the behavior of 312 firms, and demonstrated that spatial proximity to other organizations is a factor that supports cooperation, and in turn that cooperation influences innovation. From this group of authors and studies, we want to highlight two ideas: first, using measurements of innovation broader than patents is a reality and an important contribution, in the sense that it adds factors through which to measure this phenomenon. Second, the focus of the empirical evidence is mainly centered on the experiences of developed countries, while the evidence for developed countries is scarce, which opens and drives this discussion.

Pippel (2014) also contributes to the discussion by adding a perspective of non-technological innovation. This study distinguished seven different types of cooperation utilizing data from Germany, a developed country. This study proved to be an interesting basis from which to discuss the results of the present manuscript. The estimates showed that cooperation with other firms, providers, consultants, and universities are significant variables when performing non-technological innovation activities. The effect of said variables was positive, and its base had 2,417 observations. In our case, we used the situation of Chile in Latin America, a developing country. Using a base of 6,548 observations, considering both technological and non-technological innovations, we found that the significant types of cooperants were other firms, clients, and consultants. The comparison has its limitations given that the dependent variable is slightly different: Pippel (2014) studied non-technological innovation and we studied both technological and non-technological innovation. However, the group of independent variables in both cases is similar. Upon comparing the two, we noted interesting differences, given that cooperating with other firms and consultants is relevant in both contexts. Cooperation with universities and providers did not turn out to be significant for the context developing country, which could be a product of this same context, given that a developing country could be farther from high value productions and closer to raw material production. Cooperating with clients was not found to be significant in the context of a developed country, but it was found to be significant in a developing country. A possible explanation for this finding that, given the maturity of firms in developing countries, they might seek to close deals more quickly with their clients.

An idea that we do not incorporate in this document, but which could be an interesting idea for future work, is reverse causality. The work of Baraldi, Cantebene & Perani (2013) give an approach this idea. If we apply the concept of reverse causality, in our document, it would be equivalent to thinking that not only cooperation that influences innovative activities, but that, innovative companies could be more willing to cooperate.

The results of our study provide a contribution to the discussion on innovation and cooperation, given that we found differences in the ways that firms address cooperation within different contexts. The type of agent that the firm cooperates with changes depending on the level of development of the country in which it is located.

7. Conclusions

There is abundant empirical evidence that supports the relationship between cooperation and innovative business activity in developed countries, but the discussion continues to be scarce in the context of developing countries.

In the context of a developing country, a firm that reports on cooperation conducts more innovative activities per year than those that do not. The type of agent with which they cooperate is relevant in this context. In particular, other firms, clients, and consultants showed stronger and more stable results than cooperation with other types of agents.

The novelty of the study lies in our demonstration of the fact that there are differences in the effect of cooperation on innovative activities in firms from developed and developing countries. Also, our data incorporates a broader measure of innovation, as we incorporate technological and non-technological innovations for various industrial sectors. Lastly, the econometric technique used recognizes the problem of the abundance of zeros and allowed us to estimate both a first innovative activity, which is to say a change from 0 to 1, and an increase in innovative activity, i.e. a change from 2 to 12.

Our results provide a significant contribution to the discussion on innovation and cooperation, given that we found differences in how firms address cooperation when the context is different. The type of agent the firm decides to cooperate with changes when we change the context from a developed country to a developing one. These results could help to focus the efforts of private or public institutions that support innovation processes in firms, especially in developing countries.

Future studies should analyze various reasons that may explain why the type of agent the firm decides to cooperate with is different between the contexts of developed and developing countries. Furthermore, this study should be replicated with the same technique for measuring innovation, since the results of Pippel (2014), with which the results of the present work are compared, considered non-technological innovations, and our study considered both technological and non-technological innovations. Future studies should also utilize larger bases on a national level, as in the case of Goel & Nelson (2018). Lastly, more multi-disciplinary studies should be developed, since studies such as those of Jones, Klapper, Ratten, & Fayolle (2018) highlight that in order to deepen our knowledge, a focus that involves various disciplines is necessary.

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Appendix

Table A.1. Pearson correlation of innovation's type and cooperation source

	Innovation type	
	Technological	Non-Technological
Client	0.4106	0.7212
Provider	0.4901	0.6217
University	0.3838	0.7127

Table A.1. Pearson correlation of innovation's category and cooperation source

	Innovation in			
	Production	Process	Organization	Marketing
Client	0.4991	0.5539	0.5593	0.4527
Provider	0.4982	0.5572	0.5517	0.4422
University	0.4192	0.4663	0.4789	0.3817

El Papel de la Cooperación para Desarrollar Innovación Tecnológica en la PYME

Mauricio Castillo-Vergara[1] Enrique Torres Aranibar [2]*

Resumen: La innovación se ha consolidado como una vía para mejorar el desempeño de las economías. El objetivo del estudio es analizar el rol de las cooperaciones y los efectos en la innovación tecnológica y el desempeño de las empresas aplicando PLS-SEM. Para probar el modelo se utilizó la décima encuesta de innovación del Ministerio de Economía de Chile, levantada durante el año 2017. Los resultados muestran que la cooperación comercial y cooperación profesional tienen efecto en la innovación tecnológica, sin embargo, la cooperación académica no produce efecto significativo. Se han identificado acciones que permitan mejorar el sistema de innovación.

Palabras Claves: Innovación; Cooperación; Desempeño; Economía Emergente; PYME.

The role of cooperation to develop technological innovation in SMEs

Abstract: Innovation has established itself to improve the performance of economies. The objective of the study is to analyze the role of cooperation's and the effects on technological innovation and the performance of companies applying PLS-SEM. To test the model, the tenth innovation survey of the Ministry of Economy of Chile, carried out during 2017, was used. The results show that commercial cooperation and professional cooperation influence technological innovation, however, academic cooperation has no significant effect. Actions that improve the innovation system have been identified.

Keywords: Innovation; Cooperation; Performance; Emerging Economy; SME

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Introducción

La innovación es una vía para generar desarrollo económico y crecimiento (Tello Gamarra, Machado Leo, Silva Avila, & Wendland, 2019) y ocupa un lugar destacado en la agenda estratégica de la mayoría de las economías (Casanova, Cornelius, & Dutta, 2017). Un factor importante dentro de la supervivencia económica de una empresa es el desarrollo de una ventaja competitiva (Lafuente, Leiva, Moreno-Gómez, & Szerb, 2019), la cual puede potenciarse mediante la innovación (Höflinger, Nagel, & Sandner, 2017).

Para fomentar la innovación dentro de las empresas se requiere adquirir conocimientos (Scandura, 2016), de hecho, parte del proceso de innovación incluye el intercambio de información, la resolución de problemas y el aprendizaje entre personas u organizaciones heterogéneas (Edwards-Schachter, 2018). Para innovar con éxito, las empresas deben participar cooperativamente para acceder a recursos y capacidades con otras entidades (Heidenreich, Landsperger, & Spieth, 2016). Esta acción es necesaria para crear nuevos productos, procesos y tecnologías, especialmente en economías emergentes, donde los recursos y capacidades de innovación son relativamente limitados (Rojas, Solis, & Zhu, 2018). Se afirma que la innovación no ocurre aislada, sino destacando el papel de las interacciones entre organizaciones, el gobierno y las instituciones de investigación (Tello Gamarra et al., 2019) y y existe un llamado para estudiar el impacto de las actividades innovadoras en el desempeño de la empresa (Hashi & Nebojsa, 2013).

A pesar de la creciente investigación sobre innovación, existen una brecha que la literatura ha explorado insuficientemente y que este artículo intenta explicar. Los estudios en el contexto de la pequeña y mediana empresa (PYME) ha recibido poca atención (Abdul-Halim, Ahmad, Geare, & Thurasamy, 2019; Lavoie, Lavoie, Abdulnour, Lavoie, & Abdulnour, 2015), en particular en países emergentes (Heredia Pérez, Geldes, Kunc, & Flores, 2019) y el conocimiento que se ha desarrollado sobre prácticas de innovación en grandes empresas no es fácilmente transferible a la PYME (Radziwon & Bogers, 2018).

Durante la última década, el gobierno de Chile ha impulsado medidas para mejorar el sistema nacional de innovación (Guimón, Chaminade, Maggi, & Salazar-Elena, 2018), duplicando el presupuesto para proyectos de innovación (Heredia, Geldes, Kunc, & Flores, 2019). En Chile. cifras de la Corporación de Fomento de la Producción (CORFO) indican que el presupuesto destinado a proyectos de innovación ha aumentado en un 200%, con una cobertura de más de 270.000 beneficiarios durante el período 2009 – 2013 (CORFO, 2013). Sin embargo, según la última encuesta de innovación sólo el 15,1% de las empresas Chilenas ha innovado (Instituto Nacional de Estadisticas, 2018), situación que comparte con otros países latinoamericanos y emergentes (Geldes & Felzensztein, 2013). Con lo anterior, Chile representa un entorno interesante para los fines de la investigación. Abordar la relación entre cooperación e innovación resulta interesante para las PYMES (Perkins, Lean, & Newbery, 2017, y estas se pueden ver favorecidas, ya que el desarrollo de innovación es considerado un desafío central de las empresas (Sarooghi, Libaers, & Burkemper, 2015).

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Para innovar con éxito, las empresas deben participar en la cooperación para obtener acceso a recursos y capacidades de otras entidades (Heidenreich et al., 2016), aún cuando, un cuerpo de investigación se ha ocupado de la cooperación en general, la investigación sobre cooperación que apunta específicamente a fomentar la innovación ha recibido menos atención (Weber & Heidenreich, 2018) y parece de suma importancia saber que tipo de cooperación es la más efectiva para mejorar el resultado de la innovación, pero los estudios sobre los efectos de la cooperación en el desempeño de la innovación son escasos (Park, Srivastava, & Gnyawali, 2014).

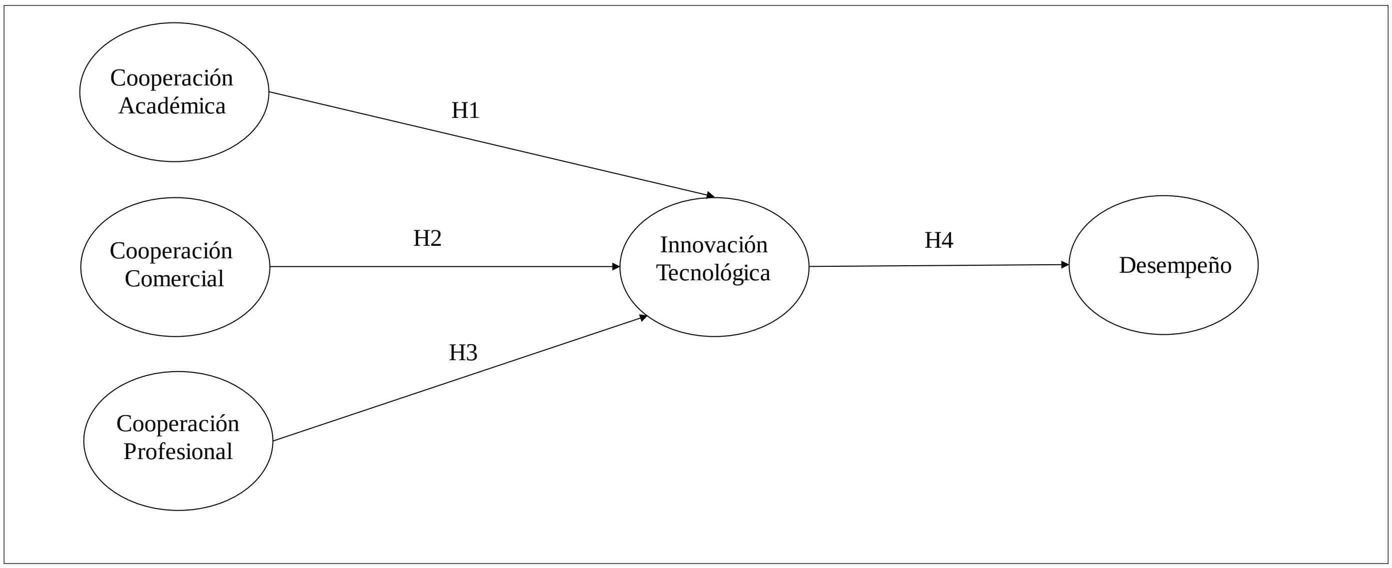
Esta noción de cooperación sugiere que los actores no son independientes ni autosuficientes y que necesitan interactuar con otros para obtener beneficios, como adquirir conocimiento y recursos para la innovación (Chou & Zolkiewski, 2018). La cooperación puede existir en muchos niveles diferentes, entre individuos, equipos y departamentos, organizaciones y redes (Lindström & Polsa, 2016), en este documento consideramos la cooperación de forma sistémica al explorar los diferentes tipos de cooperación: cooperación académica (Universidades, Institutos de Investigación y Artículos Científicos), cooperación comercial (Clientes, Proveedores, Competidores y Consultores) y cooperación profesional (Profesional e Industrial, Conferencias, Ferias o Exposiciones y Profesionales al interior de las organizaciones).

El documento está organizado de la siguiente manera. En la siguiente sección, se presentan el modelo y las hipótesis a evaluar. Los datos y métodos utilizados para probar estas hipótesis se discuten en la sección metodología. En resultados y discusión se informan y discuten los resultados. Finalmente, se identifican conclusiones, limitaciones y propuestas de investigación futura.

Modelo

El modelo de estudio propuesto se estructura como se indica en la figura 1, que señala la existencia de seis constructos. Para implementar empíricamente el modelo se utilizan ecuaciones estructurales basadas en mínimos cuadrados parciales (PLS) y se aplica el uso del software SmartPLS versión 3.2.8 (Ringle, Wende, & Becker, 2017).

Figura 1. Conjunto de relaciones descritas en las hipótesis



Fuente: Elaboración Propia

Cooperación académica e innovación tecnológica

Zeng, Xie y Tam (2010) mencionan que las universidades y los institutos de investigación tienen un impacto valioso dentro del proceso de creación de conocimiento e innovación y generalmente ocurren mediante un intercambio explícito de conocimiento (Ben Arfi, Hikkerova, & Sahut, 2018). Este tipo de cooperación es importante para empresas sin experiencia en I+D interna e incluso para aquellas que desean potenciar sus capacidades internas de innovación (Serrano-Bedia, López-Fernández, & García-Piqueres, 2018). Las fuentes externas de conocimiento pueden agruparse en tres categorías: universidades, institutos de investigación y empresas intensivas en conocimiento (Vivas & Barge-Gil, 2015).

La colaboración entre la universidad y la industria para I+D e innovación ha ido en aumento los últimos años debido a la combinación de estímulos y presiones tanto en la industria (cambios tecnológicos, globalización, ciclos de vida del producto más cortos y tiempo de comercialización, etc.) como en las universidades (financiación externa, políticas gubernamentales, etc.) (Giannopoulou, Barlatier, & Pénin, 2019). Por otro lado, los institutos de investigación públicos son uno de los actores más importantes dentro de los sistemas nacionales de innovación (Intarakumnerd & Goto, 2018). Los beneficios de la cooperación académica dentro del proceso de innovación son diversos, como por ejemplo optar a equipos de laboratorio, compartir riesgos y adquirir conocimientos complementarios (Lin, 2017), es por esto que se plantea la siguiente hipótesis:

H1: La cooperación académica afecta positivamente la innovación tecnológica

Cooperación comercial e innovación tecnológica

Desde la perspectiva de la competencia, se espera que las empresas que cooperan obtengan más beneficios de innovación y aprovechen en mayor medida los activos de las alianzas (Park et al., 2014). Sin embargo, cooperar con los competidores no es la única forma en que una empresa adquiere y desarrolla capacidades de innovación de productos, existe una tendencia creciente a aplicar la cooperación entre los socios de la cadena de suministro como una estrategia eficiente para crear valor (Resende et al., 2018). A nivel comercial, algunas contribuciones han tratado con empresas que cooperan con competidores, proveedores, clientes (Dorn, Schweiger, & Albers, 2016). En el contexto de la PYME se apunta a ganar poder de negociación mediante la cooperación con competidores (Schiavone & Simoni, 2011) e ingresan de mejor manera en algunos mercados colaborando con competidores o clientes (Akdoğan & Cingšz, 2012). La cooperación incluye varios jugadores, como los clientes, proveedores, complementadores y socios (Bengtsson & Raza-Ullah, 2016) y puede promover la innovación a través de la competencia (Gnyawali & Park, 2011). Académicos sostienen que la cooperación mejora el intercambio de información, ayuda a obtener economías de escala, reduce la incertidumbre y los riesgos y acelera el desarrollo de nuevos productos (Wu, 2014), dado que las actividades de las empresas están relacionadas con actividades y conocimiento de una serie de contrapartes. (Chou & Zolkiewski, 2018). Con estos antecedentes se plantea la siguiente hipótesis:

H2: La cooperación interempresarial afecta positivamente la innovación tecnológica

Cooperación profesional e innovación tecnológica

La cooperación profesional son para las organizaciones el medio por el cual pueden acceder a fuentes de información externa, que son necesarias para involucrarse en nuevos mercados (Bolívar-Cruz, Fernández-Monroy, & Galván-Sánchez, 2017), y la cooperación simultáneas de diversas fuentes pueden facilitar la innovación y la creatividad dentro de los equipos (Dorn et al., 2016). Estos impulsores se relacionan con la empresa (Bengtsson & Raza-Ullah, 2016) y se ha destacado la relevancia de las colaboraciones para la innovación en las empresas, incluyendo específicamente varios contactos profesionales (Trigo, 2011), con lo cual la cooperación favorece la generación y difusión de conocimiento e innovación (Bolívar-Cruz et al., 2017). Con lo anterior se plantea la siguiente hipótesis:

H3: El desarrollo de I+D intramuro afecta positivamente la innovación tecnológica

Innovación tecnológica y desempeño

La literatura relacionada con el éxito de la innovación tecnológica en el rendimiento de las empresas es extensa y ha sido respaldada en diversos sectores (Ferreira, Coelho, & Moutinho, 2018; Genc, Dayan, & Genc, 2019). Las innovaciones tecnológicas permiten responder rápidamente a las necesidades de los clientes, ganar participación de mercado, aumentar la calidad y variedad de los productos (Fossas-olalla, Minguela-rata, & Fernández-menéndez, 2015), una mayor propensión a innovar se asocia con un mejor desempeño del mercado de exportación y financiero (Hughes et al., 2018). La innovación también aparece como un motor crítico para el desempeño (Gunday, Ulusoy, Kilic, & Alpkan, 2011). Ferreira et al. (2018) explica el crecimiento de una empresa a través de la innovación y tiene un efecto positivo en el rendimiento del negocio (Atalay, Anafarta, & Sarvan, 2013; Crespell & Hansen, 2008; Rajapathirana & Hui, 2017) y en el rendimiento financiero (Karabulut, 2015). Estos hallazgos conducen a la siguiente hipótesis:H4: La innovación tecnológica afecta positivamente el desempeño de las empresas

Metodología

Datos utilizados

Para probar las hipótesis y el modelo, se ha utilizado la base de datos correspondiente a la "Décima Encuesta de Innovación en Empresas" del Ministerio de Economía de Chile, levantada durante el año 2017 tomando como años de referencia a 2015 y 2016 (Instituto Nacional de Estadisticas, 2018). El diseño y metodología siguen los lineamientos sugeridos por la (OECD/European Communities, 2005). Los datos corresponden a 5.876 empresas, de este conjunto de datos, se han seleccionado 3.252 empresas que corresponden a 2.048 empresas categorizadas en pequeñas (entre 11 y 50 trabajadores) y 1.474 empresas categorizadas en medianas (entre 51 y 250 trabajadores), según el número de trabajadores promedio entre los años 2015 y 2016, no se ha seleccionado ningún sector ni región en particular.

Variables utilizadas

La principal característica de la encuesta de innovación es que contiene un detalle de la introducción de los diferentes tipos de innovación y desempeño en las empresas. También incluye diferentes fuentes de cooperación en actividades innovativas, la confección de las variables se ha construido de acuerdo con el siguiente detalle:

Cooperación Académica: Importancia de aquellas fuentes de cooperación para el desarrollo de actividades innovativas en los años 2015 y/o 2016. Se ha utilizado la intensidad del tipo de cooperación empleada, medida como alta, media, baja o nula (Weber & Heidenreich, 2018). Tanto por las universidades u otras instituciones de educación superior e institutos de investigación públicos. Adoptamos la propuesta de Szücs (2018), respecto a las colaboraciones académicas que incluyen universidades, así como colaboraciones con instituciones de investigación y revistas científicas, publicaciones técnicas y comerciales, y bases de datos de patentes.

Cooperación Profesional: Importancia de aquellas fuentes de cooperación para el desarrollo de actividades innovativas en los años 2015 y/o 2016. Se ha utilizado la intensidad del tipo de cooperación empleada, medida como alta, media, baja o nula (Weber & Heidenreich, 2018). Las preguntas trataron los siguientes aspectos: Para las actividades innovativas la empresa utilizó en los años 2015 y/o 2016 señale la importancia de cooperaciones a nivel profesional e industrial, conferencias, ferias o exposiciones y profesionales al interior de las organizaciones.

Cooperación Comercial: Importancia de aquellas fuentes de cooperación para el desarrollo de actividades innovativas en los años 2015 y/o 2016. Se ha utilizado la intensidad del tipo de cooperación empleada, medida como alta, media, baja o nula (Weber & Heidenreich, 2018). Las preguntas trataron los siguientes aspectos: Para las actividades innovativas la empresa utilizó en los años 2015 y/o 2016 señale la importancia de cooperaciones con clientes, proveedores, competidores y consultores.

Innovación Tecnológica: Utilizamos la escala que distingue innovación de producto y proceso como indicadores dicotómicos, 0 para respuesta negativa y 1 si la empresa introdujo en los años 2015 y/o 2016 los siguientes aspectos: (1) Bienes nuevos o significativamente mejorados (excluye la simple reventa de productos nuevos comprados a otras empresas y los cambios de carácter exclusivamente estéticos (2) Servicios nuevos o significativamente mejorados (3) Un nuevo o significativamente mejorado método de manufactura o producción de bienes o servicios (4) Una nueva o significativamente mejorada actividad de soporte para sus procesos, tales como sistema de mantención u operaciones de compras, contabilidad o informática.

Desempeño: Para la construcción del desempeño, se incluyen resultados del producto o proceso (Laforet, 2013) e incluye preguntas sobre la importancia de las innovaciones de productos y procesos (Gunday et al., 2011) en los años 2015 y/o 2016. Las preguntas trataron los siguientes aspectos: (1) Ampliación de la gama de bienes y servicios, (2) Ingreso a nuevos mercados o incrementos de la participación en el mercado actual, (3) Mejora en la calidad de los bienes y servicios, (4) Aumentar la capacidad y/o flexibilidad para la producción de bienes y servicios, (5) Reducción de costos por unidad producida y (6) Reducción de impacto medioambiental o mejorar la sanidad y la seguridad.

Método de Análisis

En las últimas décadas los modelos de ecuaciones estructurales (SEM) se han convertido en una importante herramienta del análisis multivariante y su uso se ha extendido en la investigación en ciencias sociales (Cepeda Carrión & Roldán Salgueiro, 2004). Los SEM combinan el uso de variables no observadas (latentes) que representan conceptos teóricos y datos que provienen de medidas (indicadores o variables manifiestas), los que son usados como insumos para proporcionar evidencia sobre las relaciones entre las variables latentes (Williams, Vandenberg, & Edwards, 2009). Los modelos valoran en un análisis único, el modelo de medida y el modelo estructural (Gefen, Straub, & Boudreau, 2000). El análisis de los SEM puede ser llevado a cabo por dos tipos de técnicas: basados en el análisis de las covarianzas o basados en la varianza (Barroso, Cepeda Carrión, & Roldán, 2010). Ambos enfoques han sido diseñados para objetivos distintos, mientras el método basado en el análisis de las covarianzas se enfoca en estimar un conjunto de parámetros del modelo para que la matriz de covarianza teórica implícita por el sistema de ecuaciones estructurales esté lo más cerca posible de la matriz de covarianza empírica observada dentro de la muestra de estimación (Reinartz, Haenlein, & Henseler, 2009), el método Partial Least Squares (PLS) utiliza bloques de variables (componentes) y estima los parámetros del modelo por medio de la maximización de la varianza explicada de todas las variables dependientes (incluidas latentes como observadas) (Chin, 1998). Partial Least Squares puede ser usado con múltiples propósitos, y es una técnica adecuada para fines de exploración, explicación o confirmación si un modelo de ecuación estructural contiene una o más construcciones operativas como un compuesto (Henseler, 2018). Como se indicó previamente, será utilizada la herramienta SmartPLS 3.2.8 (Hair, Hult, Ringle, & Sarstedt, 2017). La técnica se ha seleccionado por presentar ciertas ventajas, no impone suposición de distribución específica (p.ej. normalidad) para los indicadores y no necesita que las observaciones sean independientes unas de otras (Chin, 2010), los requerimientos sobre escalas de medida son mínimos (Wold, 1984) y no requiere uniformidad en las escalas de medida (Sosik, Kahai, & Piovoso, 2009).

El método PLS permite el uso de tres tipos de modelos de medida: formativos, reflectivos y modelos compuestos (Henseler, Ringle, & Sarstedt, 2016), y su elección debe sustentarse en la naturaleza del constructo (Henseler, 2016). Siguiendo a (Xu, Peng, & Prybutok, 2019) todos los indicadores de las variables en estudio se han analizado como modo compuesto tipo A.

Resultados

Tal como se ha señalado en este estudio se utiliza la técnica PLS, cuya aplicación consta de dos pasos: (1) La evaluación del modelo de medida y (2) la evaluación del modelo estructural (Barclay, Higgins, & Thompson, 1995). Se estima el modelo estructural saturado aplicando un proceso de bootstrapping (5,000 submuestras) (Henseler, Hubona, & Ray, 2016). El Residual Cuadrado Medio Residual Estandarizado (SRMR = 0,055) está por debajo de 0,08 sugerido por (Hu & Bentler, 1999), con esto, se obtiene evidencia empírica para los constructos operacionalizados.

Siguiendo las recomendaciones de (Müller, Schuberth, & Henseler, 2018) se debe establecer la confiabilidad de los indicadores y constructos, la validez convergente y validez discriminante. La carga (λ) de cada elemento en su construcción debe ser superior a 0,707 para verificar la confiabilidad del indicador (Hair et al., 2017), aún cuando tres elementos se encuentran por debajo de 0,707 estos fueron retenidos según lo sugerido por (Martelo-Landroguez, Cegarra Navarro, & Cepeda-Carrión, 2019). Para establecer la confiabilidad del constructo el coeficiente alfa de Cronbach debe ser superior a 0,8 para ser considerado excelente y sobre 0,65 para ser considerado aceptable (Castillo-Vergara, Barrios Galleguillos, Jofré Cuello, Alvarez-Marin, & Acuña-Opazo, 2018), la fiabilidad compuesta y el indicador Dijkstra-Henseler's (rhoA) deben ser superior a 0,7 (Hair et al., 2017) y para establecer la validez convergente los valores deben ser mayores a 0,5 (Fornell & Larcker, 1981). En la tabla 1 se presentan los resultados para cada uno de los constructos, estos resultados indican que los modelos de medición son internamente consistentes y confiables y se obtiene una validez convergente aceptable.

Tabla 1. Resultados para la evaluación de medidas

Constructo	Ítems	Carga (λ)	Fiabilidad Compuesta	Alpha de Cronbach	rho A	AVE
Cooperación Académica	ACA1	0,799	0,819	0,682	0,708	0,602
	ACA2	0,715				
	ACA3	0,811				
Cooperación Profesional	PRO1	0,810	0,812	0,663	0,708	0,592
	PRO2	0,802				
	PRO3	0,690				
Cooperación Comercial	COM1	0,818	0,836	0,740	0,762	0,563
	COM2	0,804				
	COM3	0,730				
	COM4	0,636				
Innovación Tecnológica	IT1	0,731	0,811	0,691	0,708	0,517
	IT2	0,736				
	IT3	0,724				
	IT4	0,685				
Desempeño	EF1	0,942	0,980	0,976	0,708	0,891
	EF2	0,956				
	EF3	0,929				
	EF4	0,950				
	EF5	0,942				
	EF6	0,944				

Fuente: Elaboración Propia

Para la evaluación de la validez discriminante se aplica el criterio Fornell-Larcker, que para lograr la validez discriminante, la raíz cuadrada del AVE de un constructo debe ser mayor que la correlación que éste tenga con cualquier otro constructo (Fornell & Larcker, 1981) y la relación de correlaciones heterotrait-monotrait (HTMT) (Henseler, Ringle, et al., 2016), cuyos valores deben ser significativamente menores que uno y como umbral valores de 0,85 o 0,9 para indicar pruebas suficientes de validez discriminante (Henseler, Ringle, & Sarstedt, 2015). En las tablas 2 y 3 se muestran los resultados del criterio Fornell-Larcker y HTMT, de acuerdo con los resultados, se concluye que la validez discriminante está asegurada.

Tabla 2. Evaluación de la validez discriminante de los constructos modelados (criterio de Fornell-Larcker).

	Desempeño	**Innovación Tecnológica**	**Cooperación Comercial**	**Cooperación Profesional**	**Cooperación Académica**
Desempeño	**0,944**				
Innovación Tecnológica	0,754	**0,719**			
Cooperación Comercial	0,489	0,514	**0,751**		
Cooperación Profesional	0,512	0,548	0,703	**0,769**	
Cooperación Académica	0,272	0,317	0,489	0,647	**0,776**

Nota: las variaciones medias extraídas (AVE) se muestran en diagonal en negrita.
Fuente: Elaboración Propia

Tabla 3. Evaluación de la validez discriminante de los constructos modelados (HTMT).

	Desempeño	Innovación Tecnológica	Cooperación Comercial	Cooperación Profesional	Cooperación Académica
Desempeño					
Innovación Tecnológica	0,900				
Cooperación Comercial	0,567	0,706			
Cooperación Profesional	0,607	0,780	0,894		
Cooperación Académica	0,322	0,440	0,682	0,862	

Fuente: Elaboración Propia

Para evaluar el modelo estructural, deben ser consideradas la valoración de posibles problemas de colinealidad en el modelo estructural, la evaluación del signo algebraico, magnitud y significación estadística de los coeficientes path, valoración del coeficiente de determinación (R2) y valoración de los tamaños de los efectos (f2) (Ali, Rasoolimanesh, Sarstedt, Ringle, & Ryu, 2018). De acuerdo con (Hair Jr., Sarstedt, Hopkins, & Kuppelwieser, 2014) existirán indicios de multicolinealidad si valor FIV del modelo estructural son mayores que 5. El valor R2 representa una medida del poder predictivo e indica la cantidad de varianza en el constructo en cuestión, que se explica por sus variables antecedentes en el modelo (Roldán, Sánchez-Franco, & Real, 2017), los valores de R2 deben ser lo suficientemente altos para que el modelo alcance un nivel mínimo de poder explicativo, como mínimo mayor o igual a 0,10 (Frank & Miller, 1992). Las estimaciones del coeficiente path debe ser estadísticamente significativo en función del intervalo de confianza del percentil de arranque y su signo debe ser coherente con la hipótesis planteada (Rasoolimanesh, Md Noor, Schuberth, & Jaafar, 2019).

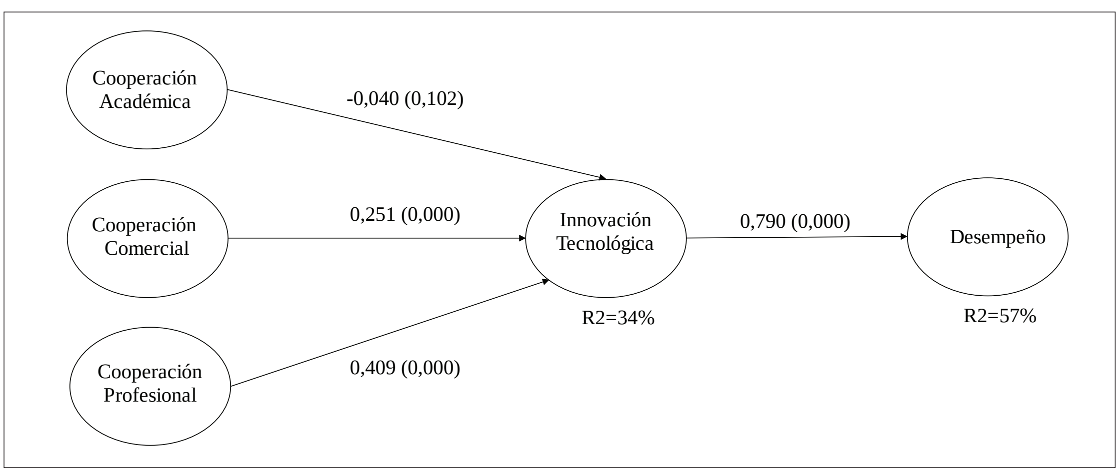
Los valores R2 significativo para innovación tecnológica (33,7%) y para desempeño (56,8%). En la tabla 5 se presentan los resultados para el modelo estructural que respalda la aceptación o rechazo de las hipótesis. La figura 2 presenta el modelo en estudio, se ha calculado el coeficiente Stone-Geisser Q2 (Gefen et al., 2000), utilizando el procedimiento blindfolding para medir la relevancia predictiva de las variables latentes endógenas, y se ha obtenido un valor de 0,164 para innovación tecnológica y 0,504 para desempeño, como criterio de evaluación, se deben obtener valores mayores a cero y un modelo perfecto tendría Q2 = 1 (Hair Jr. et al., 2014).

Tabla 5. Resultados del Modelo Estructural. Nota: *** Significativa p<0,001

Hipótesis		Efecto Directo	t-value	Intervalo de Confianza (Percentile Bootsrap)	Hipótesis
H1	Cooperación Académica – Innovación Tecnológica	-0,040	1,272	[-0,886 – 0,017]	Rechaza
H2	Cooperación Comercial – Innovación Tecnológica	0,251	6,816	[0,193 – 0,314]	Aprueba***
H3	Cooperación Profesional – Innovación Tecnológica	0,409	11,100	[0,347 – 0,469]	Aprueba***
H4	Innovación Tecnológica – Desempeño	0,790	84,272	[0,776 – 0,807]	Aprueba***

Fuente: Elaboración Propia

Figura 2. Modelo en estudio y resultados



Fuente: Elaboración Propia

Discusión

Se analizaron empíricamente las relaciones entre tres tipos de cooperación y el desarrollo de innovación tecnológica en la PYME, así como el impacto que esta tiene en el desempeño, según datos de PYMES chilenas. Los resultados mostraron que tanto la cooperación comercial como la cooperación profesional tuvieron efectos positivos significativos en el desarrollo de innovación tecnológica en empresas pequeñas y medianas, cuestión que está en línea con los argumentos de la literatura, como por ejemplo, (Bengtsson & Raza-Ullah, 2016; Bolívar-Cruz et al., 2017; Resende et al., 2018). Particularmente considerando el papel de los diferentes actores de los ecosistemas de innovación en Chile, los resultados parecieran estar alineados con los diferentes instrumentos que el estado impulsa, programas que buscan generar proyectos que permitan sistematizar la gestión con apoyo de una entidad experta o el poyo para la implementación de centros que contribuyan a mejorar la productividad de las empresas de menor tamaño, fortalecimiento de capacidades para innovar y la vinculación con el ecosistema. Las políticas gubernamentales actuales son en gran medida propicias para mejorar la vinculación con la PYME y la cooperación con clientes, proveedores, competidores y externos.

Una PYME centrada en la cooperación con proveedores, competidores, clientes o profesional conducirá a elevar sus resultados de innovación tecnológica. Entonces, es clave para este tipo de empresas mantener redes de cooperación, pero debe tenerse en cuenta que dicha relación debe establecer con claridad el tipo de modelo de cooperación, pues tal como señala (Zeng et al., 2010) la cooperación exitosa dependerá del tipo de cooperación definida.

Los hallazgos respecto a la cooperación académica y el impacto en la innovación tecnológica no son aceptados. Hay algunas explicaciones posibles para este resultado. Primero, las políticas de las instituciones académicas aún no se encuentran alineadas con el desarrollo de cooperación con empresas, la gran mayoría de las instituciones de investigación centran sus objetivos y metas en la construcción de conocimiento, y se le otorga poco valor a la cooperación o vinculación en la carrera académica. Esta dificultad, puede impedir que se mejore la relación entre las universidades y los centros de investigación con las empresas PYME. En segundo lugar, un número importante de instituciones académicas o de investigación no ha definido políticas de propiedad intelectual para sus investigadores, este escenario, inhibe la participación de estos en el desarrollo de innovación tecnológica, y en los casos en que ocurre su participación se realiza de forma profesional y no institucional. Dado que en general las empresas cooperan con Universidades y centros de investigación para acceder a conocimientos científicos, técnicos o nuevas tecnologías (Barroso Simao, Gouveia Rodrigues, & Madeira, 2016), se debieran potenciar programas gubernamentales que potencien dicha relación.

Nuestro trabajo evidencia empíricamente la relación sobre innovación y desempeño en las empresas pequeñas y medianas chilenas, dicha evidencia es importante, pues esta relación positiva se ha indicado que depende del contexto (Rosenbusch, Brinckmann, & Bausch, 2011). Las empresas grandes tienen mayores probabilidades de invertir y participar en innovación, dicha capacidad disminuye con empresas pequeñas y medianas (Hashi & Nebojsa, 2013), y nuestra contribución está en línea con lo reportado para países emergentes (Santi & Santoleri, 2017).

Conclusiones

De acuerdo con los resultados de la décima encuesta de innovación, un 19.3 % de las empresas que innovan, dice haber participado en acciones de cooperación en proyectos de innovación. Por ello, el objetivo de este estudio fue analizar los efectos de diferentes actividades de cooperación sobre la innovación tecnológica y sus efectos en el desempeño de empresas en Chile. Los resultados indican que (a) las empresas PYME que colaboran con clientes, proveedores, competidores y/o consultores presentan mejores resultados de innovación tecnológica; (b) las empresas PYME que participan en actividades de colaboración a nivel profesional e industrial, en conferencias, ferias, exposiciones y/o con profesionales al interior de las organizaciones presentan mejores resultados de innovación tecnológica y (c) el desempeño de las empresas PYME se ve afectado positivamente por el desarrollo de innovaciones tecnológicas.

Esto se puede explicar por los siguientes antecedentes en el caso de Chile, el tamaño de la empresa está relacionado con la probabilidad de que las empresas se dediquen a actividades de innovación (Benavente, 2007) y se ha sugerido que existen sinergias sin explotar entre las políticas de apoyo a la innovación y las políticas de apoyo al espíritu empresarial en el contexto de las iniciativas de desarrollo regional (Modrego, Mccann, Foster, & Olfert, 2015), las políticas públicas deben promover acciones para mejorar la relación entre las empresas y sus redes no relacionadas (Basco & Calabrò, 2016), dado que se ha propuesto que las empresas chilenas funcionan en un contexto de individualismo, lo que tiene un efecto negativo en la relación entre la innovación y el rendimiento (Rosenbusch et al., 2011).

Este estudio hace una contribución metodológica significativa a la literatura de innovación, al aplicar un análisis mediante Smart-PLS, y los hallazgos tienen una serie de implicaciones prácticas, tanto para para las empresas como para los gobiernos. Los resultados se encuentran en línea con el llamado a que las políticas públicas desarrollen programas para promover redes de innovación para ayudar a las empresas a generar innovaciones (Geldes, Felzensztein, & Palacios-Fenech, 2017). De acuerdo a nuestros resultados, se debiera propiciar una mayor cooperación entre las entidades académicas con las empresas para fortalecer la innovación tecnológica, tal como se ha planteado ampliamente (Barrie, Zawdie, & João, 2019; W. Liu & Atuahene-Gima, 2018; Ueasangkomsate & Jangkot, 2018).

Desde el punto de vista de las empresas, la cooperación es una posibilidad de reducir riesgos asociados con los procesos de innovación y compartir gastos (personal especializado, laboratorios, tecnología, estudios) si trabajan en conjunto. Las empresas que participan en actividades basadas en la cooperación estarán expuestas a flujos de conocimiento más densos que las entidades que no cooperan (Raposo, Ferreira, & Fernandes, 2014), dado que se puede facilitar el desarrollo de innovaciones al beneficiarse del acceso a diferentes conocimientos (Serrano-Bedia et al., 2018). Los gerentes de las empresas deben establecer que estrategia seguir para el desempeño de la innovación, pues genera mayores efectos la cooperación con entidades comerciales o profesionales que con instituciones académicas.

Las empresas que desarrollan innovación tecnológica tienen un impacto positivo y significativo en el desempeño de las empresas, que se ven reflejadas en la ampliación de la gama de bienes y servicios, ingreso a nuevos mercados o incrementos de la participación en el mercado actual, mejora en la calidad de los bienes y servicios, aumento de la capacidad y/o flexibilidad para la producción de bienes y servicios, reducción de costos y/o reducción de impacto medioambiental o mejorar la sanidad y la seguridad. Considerando que en Chile, un número importante de empresas PYME posee una concentración de clientes, el desarrollar innovación tecnológica tendrá efecto en el desempeño de la misma, y disminuir el riesgo de incertidumbre al concentrar en un número reducido de clientes.

Los gobiernos deben promover interacciones con las empresas, lo que puede aumentar las posibilidades de mayor desarrollo de innovación en las empresas (Stubrin, 2017) y las políticas públicas debieran abordar este desafío. Existen diversos obstáculos a la innovación (Acuna-Opazo & Castillo-Vergara, 2018), muchas de ellas se deben a la falta de recursos humanos, financieros y especializados (Iturrioz, Aragón, & Narvaiza, 2015) y existe la necesidad de una acción política más efectiva para aliviar los obstáculos que disuaden a las empresas de invertir en innovación y proporcionar mejores condiciones comerciales (Crespi & Zuniga, 2012), que incluyan la cooperación.

Nuestros resultados, no muestran resultados significativos respecto al impacto de la cooperación académica en el desarrollo de innovación en la PYME, aun cuando se ha señalado que las universidades y los institutos de investigación tienen un impacto valioso dentro del proceso de creación de conocimiento e innovación y generalmente ocurren mediante un intercambio explícito de conocimiento (Ben Arfi, Hikkerova, & Sahut, 2018). Con lo cual, futuras investigaciones podrían abordar si la cooperación académica puede mediar el desarrollo de investigación y desarrollo dentro de las empresas como determinante de la innovación. Dado que el estudio se limitó a la muestra general, futuras investigaciones podrían considerar el análisis por sectores económicos o analizar de forma separada la innovación de producto (radical e incremental) y la innovación de proceso (directas e indirectas) o innovaciones no tecnológicas.

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How Innovation Influences on Export Performance: A Configuration Approach for Emerging Economies

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Abstract: This study examines innovation on export performance under competitive strategies, institutional factors and marketing capability. We collect the information from 201 firms through surveys of four countries: Brazil, Mexico, Chile, and Peru, and we use a novel method approach (qualitative comparative analysis) to analyze how these antecedents combined to lead to the export performance. We found that the technological capability degree depends on the export market. In developed markets, firms need low technological capability, contrary when firms export to developing countries firms needs to develop high degree of technological capability. Besides, the technological capability needs to configure with implementation of strategies depends on institutional factors and marketing capability.

Keywords: Export performance; technological capability; cost strategy; differentiation strategy; qualitative comparative analysis; emerging economy

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1. Introduction

Until now, we have known or deepened the study of the external, internal, and institutional determinants of innovation (Heredia Pérez, Geldes, Kunc, & Flores, 2018). Studies in developed countries determine that technology transfer and the existence of startups increase export performance of the country level (DiPietro & Anoruo, 2006). Studies in the UK and Germany determine that innovation has a significant positive effect on companies' export performance (Love & Roper, 2015; Roper & Love, 2002). Other studies in Italy on high-tech companies have determined internal factors such as R&D employees, R&D partners, and product innovation has a positive effect on export performance (D'Angelo, 2012). Likewise, other authors complement the study by identifying internal resources that increase export performance such as skills, leadership and people management, R&D, capital and equipment investment, domestic financing, design, intellectual property management, leadership, and strategy (Love & Roper, 2015). Besides, external factors increase export performance as an increase in access to knowledge (Love & Roper, 2015). However, previous studies do not consider how does the effect of technological capability (innovation) modified under institutional factors, competitive strategies, and the export destination. The mentioned above could require to modified the level of technological capability. Also, in Latin America as an emerging economy, researchers did not study the effect of technological capability on export performance.

The study of export in the international business, marketing, and global strategy has been influential in the increase of commercial transactions between countries (Sousa, Martinez & Coelho, 2008; Aulakh, Kotabe & Teegen, 2000; Carneiro, Rocha & Ferreira, 2011; Yong Gao, & Kotabe, 2010). Export researches in emerging economies are growing fields (Yong et al., 2010; Aulakh et al., 2000). The export strategy is one of the fastest mechanisms to open new markets, especially in medium-sized enterprises and emerging economies (Yong et al., 2010; Peng, Wang and Jiang, 2008; Peng, Sun, Pinkham, & Chen (2009).

Some studies have presented contradictory relations of the influence of variables on export performance, because of the different conditions of each review, in the marketing and international business field (Sousa et al.,2008; Leonidou, Katsikeas, & Coudonaris, 2010). Several studies have used the resources and capabilities view to successfully explain a high export performance (Homburg, Krohmera, & Workman, 2004). Few studies have utilized institutional variables as essential factors of export performance, although it is a crucial variable (Yong et al., 2010; Peng et al., 2008; Peng et al., 2009).

Therefore, we explain the study of the innovation (technological capability) with the implementation of competitive strategies to achieve an excellent export performance in emerging economies with external and internal variables, such as institutional factors and marketing capability). We use the strategic tripod approach, focusing on institutional and firm's capabilities. In our study, we use a novel method, the fuzzy set qualitative comparative analysis (FsQCA), and we answer the following research questions: i) how innovation (technological capability) configured under firm and institutional view, and competitive strategies increase export performance

As a theoretical contribution, we show that firms use a high or low innovation (technological capability) to achieve a great export performance depending on the institution's and firm's variables, export destination dependence, and competitive strategies.

This research is structured as follows: it begins by providing a theoretical background of the outcome and antecedents. Next, we describe the outcome and antecedent's measurement and the FsQCA method

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used to determine which configurations lead to high export performance. Finally, we examine the results, conclusions, implications, and the value of this research for future studies.

2. TheoreticalR Background

Strategy tripod and export performance. Many research studies the relations of different variables on export performance (Katsikeas, Leonidou, & Morgan, 2000; Dhanaraj & Beamish, 2003; Leonidou et al., 2010). However, there are several contradictory results and limitations of the research conditions (Stoian, Rialp, & Rialp, 2010; Dhanaraj & Beamish, 2003; Katsikeas et al., 2000). These contradictory results are because studies usually focus on methods that analyze a single relationship between the independent variable and the dependent variable, without considering the mutual relationship between all variables and the dependent variable (Chang, Chang, Chi, Chen, & Deng , 2012). So, we will use a novel FsQCA method studied in previous studies, for example, Chen, Li & Fan (2018), and the strategy tripod approach studied in previous studies (Heredia Pérez, Kunc, Durst, Flores, & Geldes, 2018; Heredia, Flores, Geldes & Heredia, 2017) to explain export performance in a holistic way.

We will use variables based on the institutional view (Peng et al., 2008) and firm view (Barney, 1991) to explain the use of strategies in the export performance. We consider the local effect of institutions and the institutional distance variables as institutional view, and we use marketing and technological capabilities as firms view. Also, we will use the export destination dependence and two strategies (cost and differentiation strategies) how variables that explain the export performance. According to the methodology (FsQCA) we will call "antecedents" instead of "variables" to name the variables that influence on export performance.

Now, we will explain the theory of the relation between each antecedent and export performance.

Competitive strategies and performance in emerging economies. The effect of strategy implementation on export performance is essential in emerging economies (Aulakh et al., 2000), where strategy failure happens more in the implementation phase than in conceptualization (Voola and O'Cass, 2010) and is evidenced in performance (Aulakh et al., 2000; Pertusa, Molina, & Claver, 2010; Parnell, 2011; Voola & O'Cass, 2010).

Aulakh et al. (2000) argue that in Brazil, Chile, and Mexico, cost strategies increase performance in developed countries, and differentiation strategies increase performance in developing markets. Parnell (2009) states that innovation-oriented strategies are positively associated with high performance in Peru, Mexico, and the United States. On the other hand, Mexico maintains the negative relationship between low-cost strategies and performance, while the United States maintains a positive relationship between these variables. Mainly, Peruvian firms are low-cost oriented, and Mexican firms are innovative. Parnell (2009) finds that top managers in Mexico consider their strategies to be less innovative and more cost-oriented than the average manager. In Peru, top managers also consider that their strategies are more cost-oriented than average and low managers. In the United States, there is no differentiation of the type of strategy by management type. From this, the strategy differs more between countries of emerging economies than in developed economies (Parnell, 2008). Therefore, cost and differentiation strategies are essential antecedents that we must consider in the study of export performance in emerging economies.

Moreover, Acquaah & Ardekani (2008) show that it is remarkable the application of more than one strategy in a firm. In this study, they show empirically that the implementation of two combined strategies produces more excellent performance in the company on the implementation of a single strategy. Therefore, for our study, we will use as an antecedent of export performance, cost strategy, and differentiation strategy, and we will analyze if it is a necessity to combine these strategies to obtain high performance in exports.

Export destination dependence. Export destination dependence is measured as the ratio of export sales of a particular destination to total sales (Tookson & Mohamad, 2010). Prasad, Ramamurthy, & Naidy (2001) affirm that export dependence moderates the relation between export performance and marketing capabilities. Cadogan, Diamantopoulos, & Siguaw (2002) find that the ability to use marketing depends mostly on the degree of export dependence. Prasad et al. (2001) point out that the amount of resources spent on exports is linked to reliance on exports. Therefore, in our study, we expect export destination dependence to be a relevant antecedent in export performance, that is, that export performance outcome depends on the combination of export destination dependence and other antecedents. We will define export destination dependence as a developed economy and developing the economy.

Institutional Conditions and Transitions. Regarding the institutional view, we use the local effect of institutions and institutional distance antecedents. Several researchers have analyzed the influence of institutions on export performance, and show that countries with better institutions have an excellent export performance (Bernard, Eaton, Jensen & Kortum, 2003; Faruq, 2011; Rodrik, 1995). Moreover, studies find that institutional distance is negatively related to the company's performance (Chao & Kumar, 2010; Gaur & Lu, 2007). So, in our study, we will use the positive performance of institutions on the property right and the institutional distance as antecedents of export performance, and we will analyze whether these antecedents combine with other antecedents achieve the export performance.

Firm-specific Resources and Capabilities. Regarding the firm's view, we show marketing capability and technological capability as antecedents. Previous research suggests that firms with higher marketing competencies are more successful export performance than their competitors (Cavusgil & Zou, 1994; Piercy, Kaleka, & Katsikeas, 1998). About the technological capability (innovation), it is the transformation and absorption of technology to achieve technical-economic efficiency (Zawislak, Alves, Tello-Gamarra, Barbieux & Reichert, 2012). Abereijo, Adegbite, Ilori, Adeniyi, & Aderemi (2009) recommend that institutions promote technology transfer to achieve a better connection between the Science and Technology system and the firm's production. Reichert & Zawislak (2014) find that in addition to technological capability, firms need other elements to achieve high performance. Likewise, many studies have analyzed the relationship between technological capability and export performance and have found a positive relationship (Athreye & Kapur, 2015; Ernst, Ganiotsos, & Mytelka, 1995; Krammer, 2016; Wang, Cao, Zhou & Ning, 2013). Based on this analysis, in our study, we examine whether firms that achieve high export performance develops innovation (technological capability) or marketing capability as antecedents and whether they combine each other and with other antecedents.

So, based on the strategic tripod approach performed above, we find three possible configurations that lead to high export performance. a) Companies that have a high local effect of institutions (Faruq, 2011), low institutional distance (Chao & Kumar, 2010), high marketing capability (Cavusgil & Zou, 1994) high use of cost strategies and have as destination countries, developed economies (Aulakh et al., 2000), increase the export performance. b) Companies that have a high local effect of institutions (Faruq, 2011), low institutional distance (Chao & Kumar, 2010), high marketing capability (Cavusgil & Zou, 1994) use differentiation strategies and have developing economies as destination countries (Aulakh et al., 2000), increase the export performance. c) Firms that have a high local effect of institutions (Faruq, 2011), low institutional distance (Chao & Kumar, 2010), high technological capability (Guan & Ma, 2003) and combine more than one strategy (Acquaah & Ardekani, 2008) increase the export performance.

Table 1. Expectations leading to Export performance

Causal configurations	First	Second	Third
Great performance of export destination	Yes	No	~~Not relevant~~
High local effect of institutions on property right	Yes	Yes	Yes
High institutional distance	No	No	No
High marketing capability	Yes	Yes	~~Not relevant~~
High technological capability	~~Not relevant~~	~~Not relevant~~	Yes
High use of differentiation strategies	~~Not relevant~~	Yes	Yes
High use of Cost strategies	Yes	~~Not relevant~~	Yes

Source: Elaborated by the authors

3. Method

Sample and Data

Aulakh et al. (2000) affirm that the developing economies of Latin America are a particular group, given the common problems between them of inflation and external debt. We use Chile, Brazil, and Mexico data because they have a high economic growth rate in recent years, between 6% and 8% (Illescas & Jaramillo, 2011) and has been previously studied in strategy studies in Latin American emerging economies (Aulakh et al., 2000). Also, we include Peru because their exports have overgrown in volume and profitability in recent years (Illescas & Jaramillo, 2011), as a result of the application of trade opening policies (Awokuse, 2008), favorable market conditions such as the cost of metals (Illescas & Jaramillo, 2011) and productivity improvements (Tulet, 2010; Illescas & Jaramillo, 2011).

For the sample size, we consider a database of exporting companies from Chile, Brazil, Mexico, and Peru. Primary data were collected through surveys applied to managers of exporting firms from Peru, Chile, Brazil, and Mexico. Before the survey application, we validated the survey with interviews with four people in business from different countries. We realized an online survey using the Survey Monkey plan Premium software to recollect the responses. We collected the survey data between January and April 2012, and we sent a total of 4311 emails (one mail per company), addressed to executives responsible for export. A total of 262 responses, 201 were complete. Of the complete responses, 45% belong to Mexican companies, 22% to Peruvian companies, 21% to Brazilian companies and 11% to Chilean companies.

Table 2. Percentages of responses by country

Country	% Responses to surveys	Email submitted	Total responses	Incomplete responses	Complete responses	% Total responses	% Complete responses
Brazil	11%	461	51	9	42	19%	21%
Chile	10%	400	39	16	23	15%	11%
Mexico	4%	2800	100	9	91	38%	45%
Peru	11%	650	72	27	45	27%	22%
Total	6%	4311	262	61	201	100%	100%

Source: Elaborated by the authors

Research Design

FsQCA is a method based on boolean mathematics and fuzzy sets that link different paths to the same outcome (Rihoux & Ragin, 2009). In our case, the outcome is export performance. Rihoux & Ragin (2009) affirm that FsQCA is ideal for the study of complex variables, where different relationships complex leads to a single outcome. The asymmetric causality is a fascinating and particular characteristic of FsQCA. Asymmetric causality indicates that not necessarily the relations that led to the outcome presence, when it is combined oppositely will lead to the result absence (Schneider & Wagemann, 2012). Also, FsQCA, unlike conventional regression analysis, is ideal for explaining a result through several theoretical explanations and which there is evidence of asymmetric causality (Brenes, 2017; Chen et al., 2018). For our study, we will use FsQCA to link seven antecedents to high export performance.

Outcome and antecedents measure

Outcome: Export performance. The export performance was measured through a seven-point scale, which evaluated export performance through the profitability of export sales compared to the three main competitors in the last three years. (1) means deficient performance and (7) means very high performance. This measure is consistent with some previous studies (Aulakh et al., 2000; Murray, Yong et al., 2010). The next part explains the measure of antecedents.

Antecedents

- *Differentiation strategy and Cost strategy*. Our measures are based on the measurement of one of the dimensions of cost and differentiation strategies found in previous studies, such as Aulakh et al. (2000) and Voola & O' Cass (2010). We use two survey questions for each to measure these variables. For the differentiation strategy, the company was asked, whether it agreed or not, always to be the first to market a new product in the last three years. For the cost strategy, the company was asked, whether it agreed or not, to invest mainly in large projects to achieve economies of scale in the last three years. To see a descriptive tabulate of these antecedents, please see table 3.

- *Export destination dependence*. Our export destination dependence variable was measured according to the classification of developing and developed countries by Aulakh et al. (2000). The variable created was a dummy variable, where (0) meant that the destination economy was a developing country, and (1) if the destination economy was a developed country. Of the total number of firms surveyed, 69% exported to developed economies and 31% to developing economies (see table 3).

- *Institutional Conditions and Transitions*. This section presents the measures of the institutional antecedent: Institutional distance and local effect of institutions. To measure institutional distance, we used the concept of institutional distance in the normative used by Chao & Kumar (2010). In the survey, the company was asked about the perception of institutional differences between the export home country and the export destination dependence (measured according to profitability in the last three years) about regulations on customs regulations. Moreover, to measure the local effect of institutions, we used one of the three institutional dimensions used by Faruq (2011): property rights. In the survey, the company answered whether the performance was negative or positive of local institutions (public and private) of the property right on the export activity of their company in the last three years. To see a descriptive tabulate of these antecedents, please see table 3.

- *Firm-specific Resources and Capabilities*. This section presents the measures of the antecedents that are related to the characteristics of firms: marketing capability and technological capability. Conant, Mokwa & Varadarajan, (1990) and Desarbo et al. (2005) measures marketing capabilities through the knowledge of customers, competition, integration of marketing programs, skills in targeting and effectiveness of advertising programs, and cost. In our study, we use the effectiveness of advertising programs as a measure of marketing capability. In the questionnaire, the company was asked how well or poorly they believe that their company carries effective promotion and advertising programs compared to the three main competitors. Technological capability. In the questionnaire, the company was asked how well or poorly they believe that their company can predict technological changes in the industry compared to the three main competitors. We consider this variable as a proxy of innovation, because it allow firms to scan the environment and make the fit with the competitive strategies and firm and institutional variables to increase export performance (Dobni & Luffman, 2003). To see a descriptive tabulate of these antecedents, please see table 3.

Table 3. Descriptive indicators

Variable	Observations	Mean	Standard deviation	Minimum<?>	Maximum<?>
Export performance	201	4.06	1.45	1	7
Destination economy dependence	201	0.74	0.44	0	1
Local effect of institutions on property right	201	4.90	1.50		7
Institutional distance	201	3.93	1.78		7
Marketing capability	200	4.16	1.64	1	7
Technological capability	200	4.55	1.52	1	7
Use of differentiation strategies	201	3.64	1.81	1	7
Use of Cost strategies	201	4.07	1.82	1	7

Source: Elaborated by the authors*Calibration*

[1] Lowest value.
[2] Greatest value.

It is firstly essential and vital to calibrate the antecedents and the outcome to be able to use the FsQCA method. Calibrating in FsQCA helps to understand when cases are or are not members of a category (Ragin, 2008). For our study, we used the QCA principles (Ragin, 2008; Schneider & Wagemann, 2012) to calibrate. We used the direct method of calibration, we divide into four intervals the antecedents and the outcome, taking each one as extremes to the values between 0, 0,05, 0,5, 0,95 and 1. The values 0,05, 0,5, 0,95 represent the not full membership, the crossing point and the full membership (Ragin, 2008). We show the calibration in Table 4.

Table 4. Calibrations

Type	Outcome and antecedents of export performance	Measurement	Membership score	Fuzzy Membership
Outcome	Export performance	Exports performance was measured through the profitability of export sales compared to the three main competitors in the last three years. (1) means very low performance and (7) means very high performance	Very high performance = 7	0.95
			Average performance = 4	0.5
			Very low performance = 1	0.05
Market strategy	Differentiation strategy (High frequency in being the first to commercialize a new product)	The firm was asked, whether it agreed or not, always to be the first to market a new product in the last three years.	Totally agrees = 7	0.95
			Neither agree nor disagree=4	0.5
			Totally disagrees = 1	0.05
	Cost strategy- High investment mainly in large projects to achieve economies of scale.	The firm was asked, whether it agreed or not, to invest mainly in large projects to achieve economies of scale in the last three years.	Totally agrees = 7	0.95
			Neither agree nor disagree=4	0.5
			Totally disagrees = 1	0.05
	Export destination dependence	A dummy variable, where (0) meant that the export destination dependence was a developing country and (1) if the export destination dependence was a developed country	Developed country=1	Dichotomized variables
			Developing country=0	
Resource based- view	Marketing capability	The firm was asked how well or poorly they believe that their company carries effective promotion and advertising programs compared to the three main competitors. Its values range from (1) poorly to (7) well.	Well = 7	0.95
			Average=4	0.5
			Poorly = 1	0.05
	Technological capability	The firm was asked how well or poorly they believe that their company can predict technological changes in the industry compared to the three main competitors. Its values range from (1) poorly to (7) well.	Well = 7	0.95
			Average=4	0.5
			Poorly = 1	0.05
Institution based-view	Institutional distance	The company was asked about the perception of institutional differences between the export home country and the export destination country (measured according to profitability in the last three years) about regulations on customer orientation. Values ranged from 1 to 7, where (1) meant low institutional distance and (7) meant long institutional distance.	Long institutional distance= 7	0.95
			Average institutional distance=4	0.5
			Low institutional distance = 1	0.05
	Local effect of institutions on property right	The company answered whether the performance was negative or positive of local institutions (public and private) of the property right on the export activity of their company in the last three years. Values ranged from 1 to 7, where (1) meant very negative performance of local institutions and (7) very positive.	Very positive= 7	0.95
			Average =4	0.5
			Very negative = 1	0.05

Source: Elaborated by the authors

Coverage and Consistency

FsQCA requires to analyze the consistency and coverage of the model to know representative models, supporting the researcher to select a correct FsQCA model (Brenes, 2017; Chen et al., 2018). These measures are different from the measures of significance used in other methods, such as linear regressions. Consistency measures the degree of deviation of data from a whole subset, which is represented by a numerical value. Coverage measures the degree of explanation of outcome through antecedents (Schneider & Wagemann, 2012). Consistency does have a minimum threshold, but coverage does not have a minimum threshold, because even models with low coverage could be of great interest for the explanation of an outcome (Schneider & Wagemann, 2012). We set consistency values higher than 0.8 and coverage values between 0.2 and 0.6, values that are by other studies such as Brenes (2017).

Results and discussion

Our results (see table 5) presented differences with export performance expectations (see table 1). The first difference is that even with a high institutional distance, the company can have an excellent export performance. The second difference is that the company does not necessarily apply differentiation strategies when exporting to a developing country; we observe that in configuration 2, the company uses the cost strategy to export to developing countries. Finally, the third difference is that even when local institutions have a profound effect on property rights, companies can have an excellent export performance (configurations 1 and 2).

Three configurations are linked to high export performance (see table 5). The first configuration shows that if the company has as an export destination dependence a developed economy, low local performance of the institutions on property rights, independent or not if have high institutional distance, high effectiveness of advertising, and promotion programs (high marketing capability). Moreover, the company have low ability to predict technological changes in the company (low technological capability), high frequency in being the first to commercialize a product (high use of differentiation strategy) and high investment in large projects to achieve economies of scale (high use of cost strategy) will have a significant export performance.

This type of companies export products that do not need high technology to developed countries and use a lot of marketing capability. Different investigations have shown that having low costs and maintaining excellent product quality (differentiation strategy) is effective in raising profitability in mature industries (Anderson & Zeithaml, 1984; MacMillan, Hambrick, & Day, 1982; Spanos, Zaralis & Ioukas, 2004). It is essential that companies entering developed countries achieve a high market share, so they need a combination of both strategies. Therefore, these type of companies combine the cost strategy and differentiation strategy using their marketing capability on a large scale to achieve the product to the final customer and achieve an excellent export performance. The company uses the differentiation strategy for export because it has a low effect of institutions on property rights of the export home country, which drives it to look for new markets where its product is protected. Besides, firms need to spend few technological capabilities, because customers in developed economies drive for price in mature markets. So, we propose the following:

Proposition 1: *If the company exports to a developed economy with low local effect of the institutions, has high marketing capability, has low technological capability, and uses two strategies (the cost strategy and the differentiation strategy), independent or not if have different regulations on customer orientation, it will have a high export performance.*

The second configuration shows that if the company has as an export destination dependence a developing economy, a low performance of the institutions on property rights, different regulations on customer orientation (high institutional distance), low effectiveness of advertising, and promotion programs (low marketing capability). Moreover, the company has high ability to predict technological changes in the company (high technological capability), low frequency in being the first to commercialize a product (low use of differentiation strategy) and high investment in large projects to achieve economies of scale (high use of cost strategy).

This configuration is for companies that seek to reduce their cost through large scale production, the success of that strategy depends on, principaly, the adoption of the lastest technology in production, and capital allocations for new equipment and machinery (Zahra & Covin, 1993; Desarbo, 2005). Additionally, companies that achieve cost leadership positions focus on refining their existing products rather than new models (Dess & Davis, 1984; Zahra & Covin, 1993). Therefore, since those companies focus on the process of the existing products, they tend not to consider essential to carry effective promotions and advertising programs (Zahra & Covin, 1993; Buzzell & Gale, 1987). The cost strategies tend to be used for companies that operate in context of poor local institutions of property rights since technologies of production are difficult to imitate by competitors (Frances, 2006) what at the same time does not encourage to use differentiation strategies. This strategy is further intensified if its exports go mostly to developing countries where the level of institutionality is low (Subramaniam, 2015). Also, a high institutional distance for firms that export to developing countries translates into export to countries with weak regulations to consumer due to the low degree of institutional on property rights in developing countries (Subramaniam, 2015). Finally, contrary to the first configuration, firms need to spend high technological capability to increase export performance because customers in developing countries are more sensitive to novelty.This context facilitates the export and ensures the success of the market strategy that is being used.

From the above, we find that technological capability is necessary to combine with the six antecedents of the strategy tripod to achieve export performance in developing markets. Therefore, we propose the following:

Proposition 2: *If the company exports to a developing economy with low local effect of the institutions, maintain a high institutional distance from the destination country, has low marketing capability, has high technological capability, and just uses one strategy (uses the cost strategy and does not use the differentiation strategy) it will have a high export performance.*

The third configuration reinforces the relation of high technological capability is necessary condition to increase export performance when firms dependence on developing markets. Also, the third configuration shows that firm´s technological capability needs to be combined with a high performance of the local institutions on property rights, different regulations on customer orientation (high institutional distance). Moreover, the company has high effectiveness of advertising and promotion programs (high marketing capability), high frequency in being the first to commercialize a product (high use of differentiation strategy) and high investment in large projects to achieve economies of scale (high use of cost strategy) will have a high export performance.

These are types of firms that have an excellent institutional reputation in the sale of final products for having a high local effect of institutions on property rights and require good marketing skills to reach the product to the final customer of the destination economy. Marketing capabilities support the company to harness its technological capabilities and implementing effective marketing programs. These companies use cost strategy and differentiation strategy for higher quality, better service, and lower cost to export in developing economies. Studies affirm that in emerging economies, companies that combine cost and differentiation strategy obtain more significant benefits compared to companies that apply only one strategy (Acquaah & Ardekani, 2008). We show that the combination of strategies works well in combination with marketing capability and technological capability. Also, unlike studies that show that the institutional distance negatively affects the performance of the company (Chao & Kumar, 2010; Gaur & Lu, 2007), we show that even at a high institutional distance this kind of firm achieves a high export performance. The above happens because we observe that the company uses high marketing capabilities to break the barrier of institutional distance from customer orientation, i.e., the marketing capability improves the uncertainty in the difference of consumer's regulations between the export home country and the export destination country. Additionally, Khanna, Palepu, & Sinha (2005) affirm that emerging economies usually have institutional voids, which explains that the export home country does not have complications about the regulations of the market of the export destination country and thus achieve greater success here through a high export performance. So, we propose the following:

Proposition 3: *If the company exports to a developing economy with a high local effect of the institutions, has different regulations on customer orientation, has high marketing capability, has high technological capability, and uses two strategies (the cost strategy and the differentiation strategy) it will have a high export performance.*

Table 5. Configurations leading to Export performance

Causal configurations	First	Second	Third
Export destination dependence (Yes= Developed country=1, No=Developing country)	Yes	No	No
High local effect of institutions on property rights	No	No	Yes
High institutional distance	Not relevant	Yes	Yes
High marketing capability	Yes	No	Yes
High technological capability	No	Yes	Yes
High use of differentiation strategies	Yes	No	Yes
High use of Cost strategies	Yes	Yes	Yes
Raw coverage	0.20	0.06	0.08
Unique coverage	0.20	0.03	0.04
Consistency	0.90	0.97	0.92
Solution coverage	0.30		
Solution consistency	0.91		

Source: Elaborated by the authors

Conclusion and implications

Conclusion. Our study explores the configurations that lead to a great export performance in Brazil, Mexico, Peru, and Chile using FsQCA, an innovative non-linear methodology that explains that several causal paths lead to an equifinal result for our study, export performance. To have a holistic perspective, we use the institutions and firms capabilities of the strategy tripod to classify the antecedents of export performance. We use marketing capability and technological capability as the firm's antecedents. Also, we use the local effect of the institutions and the institutional distance as institutional antecedents. Likewise, we consider the export destination dependence (Prasad et al., 2001; Tookson & Mohamad, 2010) and the differentiation and cost costs as antecedents of export performance.

The results show that firms are taking into account the export destination dependence and combine the use of strategy with at least an institutional antecedent and a firm antecedent to achieve an excellent export performance.

The first configuration shows that when low institutions perform on a property right, the company achieves a great export performance, combining differentiation and cost strategies with marketing capability. Interesting, firms need to spend low in the technological capability to catch customers in developed countries.

However, when the firms have an export destination in developing countries, is necessary to increase technological capability. The mentioned before is supported for the second and third configurations. Besides the second configuration shows that companies that seek to reduce their cost through large scale production choose to increment the level of automation of plants and facilities in order to refine their existing products rather than new models so that it is not necessary for firms to count with marketing capabilities. On the other side, the context of poor local institutions of property rights encourages companies to adopt cost strategy due to technology production is difficult to imitate. Also, the success of cost strategy it much more likely when the export is directed to a country with poor regulation on consumer.

Finally, the third configuration shows that before a great performance of the institutions on the property right and a great difference between the regulation of orientation to the client between the home country and the destination country, the company achieves a great export performance, combining the technological and marketing capability, with the use of differentiation and cost strategies. The export destination dependence is essential to achieve a great export performance.

The added value of our study is that, by analyzing different combinations of antecedents with a single result, we have a more refined, holistic, and simulated analysis of the antecedents of export performance.

Theoretical Contributions. We extend the previous studies on export performance through the strategy tripod (specifically, through institutional and firm variables) and FsQCA and explaining the effectiveness of the combinations of antecedents that drive an excellent export performance.

Until now, we found too much research on the positive effect of technological capability on export performance. However, they do not show how vary the level of technological capability under institutional factors and market destinations. Our first contribution shows firms need to spend less of technological capability in developed markets destination and high degree of technological capability in developing countries destination.

Aulakh et al. (2000) argue that the cost strategy achieves better results in developed countries. They argue that companies in emerging economies that compete with these markets have fewer advantages over human, financial, and technological resources, innovative products, and established brands of more developed countries. Also, consumer perceptions of these markets are more in line with low-cost products. Our second contribution is shown in the first configuration. We affirm that firms that export to a more developed economy achieve high performance, not only using the cost strategy but also using the differentiation strategy. Low performance of institutions over property right not encourage competition to have stable, innovative products and established brands, achieving the export firm has a market space to compete. The company uses effective marketing programs to support the application of differentiation strategy.

Besides, Aulakh et al. (2000) state that the differentiation strategy achieves excellent results in developing country markets. Consumers in developing countries perceive foreign products (regardless of where products come from) as better quality products and would be willing to pay a higher cost (Aulakh et al. 2000; Hulland, Todino & Lecraw, 1996). Our third contribution is shown in the second and third configuration where we affirm that the company can use the cost strategy (second configuration) or both strategies (second and third configuration) and achieve a great export performance for the additional factors that condition the use of each strategy. For the second configuration, we would expect companies in developing countries to be less competitive and maintain lower established brands (Aulakh et al. 2000); however, considering that there is a low performance of local institutions on property right that protects innovative products and brands, exporting companies will not use the differentiation strategy. On the contrary, they will use cost strategies based on their technological capability to achieve lower costs. In the third configuration, we expect firms in developing countries to be less competitive and maintain lower established brands (Aulakh et al. 2000). Contrary to expectations, the companies are in an institutional environment that protects property rights, institutions that protects brands and innovative products, so in addition to the cost strategy, they will use the differentiation strategy accompanied by technological and marketing capability to achieve great performance.

Practical implications

Managers take account that if they want to launch products to developed economies, they do not need to spend too much on technological capability; however if they export to developing economies they will need to spend or developed technological capability.

In the case of police makers, they will know to which specific sectors will give grants to foster technological capability. They can evaluate in a holistic way the politics to promote the exportation in developing countries.

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Portfolio Evaluation of Academic Patent: A Proposal to Brazil

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Abstract: In the current context of scarce financial resources, technology transfer offices are pressured to find ways to increase revenues through technology transfers or reduce expenses with their portfolio of technologies, especially patents. The Patent assessment seeks to detect the market potential of patents for transfer through licensing, abandonment, or maintenance. In this context, the objective of this study is to validate the leading indicators used in the patent evaluation to develop a framework for evaluating academic patent portfolio in the Brazilian context. For this, we used mapping and analysis methods of the current models besides focus group consultations, exploratory factorial analysis, and Analytical Hierarchy Process (AHP) to validate the indicators. The results show that seven factors are determinant in the evaluation of academic patents, having positive implications for the management of Intellectual Property since technology transfer decision-makers can use the factors and their identified weights as value indicators to evaluate patents with the most significant market potential.

Keywords: Patent Value Assessment; Validation of Indicators; Multiple Criteria Decision Making; Analytical Hierarchy Process

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Introduction

The Innovation Law 10.973/2004 and Law 13.243/2016 established the Center of Technological Innovation in Brazil, a structure set up by Science and Technology Institutions (STI) to manage the institutional policy of innovation, in addition to other competencies of the new lawful support.

In Brazil, however, the centers undergo structuring processes, and there is still no way to effectively manage the portfolio of assessment or valuation technologies for their licensing. Thus, there are low economic benefits. In times of scarce financial resources, technology transfer offices are pressured to find ways to increase revenues through technology transfers or reduce expenses with their portfolio of technologies, especially patents.

Patent evaluation is a useful tool to detect its market potential and contributes to portfolio management decision making. In this paper, we present some results of the patent portfolio evaluation in the international literature (Grimaldi, Cricelli, & Rogo, 2018; Hsieh, 2013/2; Santiago, Martinelli, Eloi-Santos, & Hortac, 2015; B. Wang & Hsieh, 2015/3). A common feature in the development of these models is to look for the most relevant indicators of patent analysis.

Patent appraisal models are particularly suitable for institutions dealing with an extensive portfolio. It is even more appropriate when one doesn't have many resources to evaluate each of them through a personalized approach using quantitative methods (Santiago et al., 2015). Identifying valuable patents within an organization's patent portfolio is a crucial issue for intellectual property managers (Wang & Hsieh, 2015/3). If a Science and Technology Institution (STI) achieves the know-how to evaluate a technology value through patent analysis, then it can conduct better marketing and cost-effective strategies, it will be able to make decisions rightly (Hsieh, 2013/2).

In this context, the aim of this article is to validate the leading appropriate indicators for the evaluation academic patent portfolio in the context of Brazil and contribute to the technology transfer processes, presenting a general evaluation model for Brazilian Science and Technology Institutions that may also be useful for similar cases in other Latin American countries with related limitations in terms of their ability to produce technologies from academia to market (Hansen, Agapitova, Holm-Nielsen, & Vukmirovic, 2002; Lee & Kim, 2018; Navarro, Benavente, & Crespi, 2016).

Besides this brief introduction, this paper has four sections. In the next section, In the next section, we present the theoretical framework with main concepts that guide the development of a proposal for evaluating academic patents. Then, the methodology is described, the results obtained, considered as the central point of this paper, and the conclusions and suggestions of future researches.

Theoretical references

Intellectual Property Management

Science and Technology Institutions (STI) have collaborated with patent applications around the world. In the case of Brazil, there is growth, although discontinuous, of patents number coming from universities (Amadei & Torkomian, 2009). Despite the distance from Brazil, Russia, India, China, and South Korea - BRICS (Thimoteo, 2013), universities in Brazil have been advanced both in the number of the patent application and into intellectual property (IP) management (Amadei & Torkomian, 2009; Mueller & Perucchi, 2014).

Identifying valuable patents within an organization's patent portfolio is a key issue for IP managers (Wang & Hsieh, 2015/3). "Patents continue to be one of the most readily available and reliable sources of information to evaluate a technology" (Hsieh, 2013/2, p. 307), so it is necessary for the manager to understand the value of his patent portfolio, and thus, to manage it strategically (Grimaldi et al., 2015/5).

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The analysis of the "perceived value of a patent portfolio can clearly help the decision-making process and define the best protection strategy of a company" (Grimaldi et al., 2015/5, p. 287), however, it is not easy for IP managers to estimate the value without market information, especially university patents, since they are generated from science-oriented research projects that are generally far from ready for commercialization (Hsieh, 2013/2).

The study by Póvoa & Rapini (2010) on technology transfer from Science and Technology Institutions in Brazil concluded that "about 45% of the interactions refer to the transfer of the new process and techniques, while new transfers of products represent 29.4% (Póvoa & Rapini, 2010, p. 18), demonstrating that universities and research institutes generate technologies that are not sources of new products ready for commercialization.

When one achieves the ability to evaluate the price of technology through patent analysis, it is possible to predict the priorities concerning patents already filed and new invention proposals, as well as to advise managers on the technological fields for better investments in research and development projects (Hsieh, 2013/2).

Several patent portfolio evaluation models have been proposed (Grimaldi et al., 2015/5; Hsieh, 2013/2; Lee & Sohn, 2016; Santiago et al., 2015; B. Wang & Hsieh, 2015/3). A common feature in the development of these models is the search for more relevant indicators to offer the best analysis. These indicators are based on existing literature, as well as the opinion of experts and focus groups. Next, the models used to assess the potential of patents will be addressed.

Patent Assessment Models

In order to properly manage intellectual property, organizations must be able to measure and evaluate the value of their patent portfolios (Hanel, 2006/8), and the establishment of patent indicators is key to patent analysis (Tseng, Hsieh, Peng, & Chu, 2011/2). The retrieval and evaluation of patent data should be institutionalized within the organization (Ernst, 2003).

These are indicators related to the value of patents: citations received from subsequent patents, the number of references to the patent literature, measures of family size, and successful defense against annulment claims and opposition proceedings (Harhoff, Scherer, & Vopel, 2003). Also, "the greater the breadth of patent scope, the stronger of patents impact on the value of the company" (Hanel, 2006/8, p. 925). Tseng et al., (2011/2) ranked patent indicators from previous studies into three types according to the purpose (why), technology strategy (how), and value produced (what). The indicators related to market potential, i.e., the value provided, were: patent age, corporate market value, backward reference, forward citation, family size, scope, owner, number of claims, patenting strategy, number of applications, number of co-operation between researchers, number of key inventors, and legal disputes.

Considering a statistical approach, indicators such as forward citation, grant decisions, patent families, renewals, and oppositions are used to assess the value of patents (Van Zeebroeck, 2011). He elaborated a ranking among a set of similar patents using these five indicators, synthesizing them into a single value (percentage indicator) from 1-100.

Nam, Nam, & Kim (2015/6) investigated the financial effect or stock value resulting from patent processes between Apple and other smartphone manufacturers such as Samsung and High Tech Computer Corporation (HTCC). The result showed that patents in litigation might have added value.

Considering that detecting promising academic research is vital for companies in a variety of industries (Ogawa & Kajikawa, 2015/1) if a patent is within a promising area, this has additional relative value. Liu, Cao, & Song (2014) conducted a lifetime patent analysis and the Chinese patent renewal between 1985 and 2005 and found that the patent value varies between different technological areas considerably. Wang, García, Guijarro, & Moya (2011) calculated the relative importance of patents for a group of companies in a specific industry. This importance was calculated using seven (7) indicators. These include the age of patent, the extent of protection, citations made from the patent and received by other subsequent patents, number of claims, and patent family size.

The Hsieh (2013/2) presents a hybrid method of evaluating patents and determining the strategy in the initial stage of commercialization. In this model, the target audience is Research Institutions with a patent portfolio, and the leading benefit is to establish strategic actions directed to each group of patents in the portfolio, increasing their chances of commercialization. The 20 indicators used were subjected to a factorial analysis that resulted in 4 groups of indicators: General Management Benefits (Goodwill, Revenues, Social Welfare, Licensing opportunities, Industrial clustering or Networking completeness, Spin-offs Opportunities, Business Diversification, and Research and Development (R&D) effort and staff); General Management Risks (managerial risk, increased technological risk - i.e., certification, meeting standards -, market acceptance risk, technological development or production risk, market risk, and increased expenses due to litigation); Offensive Benefits (income due to litigation, citation of patents, and market share); and Cost-Related Risks (Cost, Patent application and maintenance costs, and Expenses.

The model developed by Santiago et al., (2015), 'The framework for assessing the portfolio of technologies for licensing out', was proposed for large corporations to analyze their portfolio of patented technologies and subsequently establish royalty rate values to support the negotiation process. At this point, it serves as the rationale for the negotiation of large patent volumes. Indicators used were: Breadth (Geographical coverage), Licensing limitations (legal, strategic or technical limitations), value generation potential criterion (Technical and Marketing Aspects). The impact of marketing was divided into potential, trends, and burdens.

The authors believe that this framework is of great value to universities as well as to their technology transfer offices. Once the reference values for royalty rates have been provided, potential licensors and the university can deal with the negotiation from that rate (Santiago et al., 2015).

A model proposed by Grimaldi et al., (2015/5), 'The patent portfolio value analysis: a new framework to leverage patent information for strategic technology planning', is a practical and replicable evaluation model that removes strategic patent information combining economic- with bibliometric-technological details, in order to support the decision-making process of patent managers and verify their compliance with the technological and innovative strategy in the company. They use determinants of patents value that are extracted from patent databases: Technical scope; Forward citation frequency; International scope; Patenting strategy; and Economic relevance. The model makes it possible to suggest which strategic changes can improve the value of the portfolio, or which significant actions should be implemented, such as portfolio licensing or sales, rather than technology production. For Grimaldi et al., (2015/5, p. 287), the portfolio value refers to the "power of the portfolio to support the company's value creation process and its strategic business objectives." The study by Wang & Hsieh (2015/3) resulted in the model 'Measuring the value of patents with fuzzy multiple criteria decision making'. The authors re-examined the criteria used by model researchers to evaluate patent portfolios. The authors concluded that these criteria were incomplete, differed widely between studies, were not always independent, assessed only a small number of patents, and, in general, they were from a specific sector. The indicators of Wang & Hsieh (2015/3) are a) Strategic Patent Values (innovation, technology competitiveness, business potential, and organizational growth; b) Patent protection values (Quality and residual life cycle); and c) Values of marketing (new products initiated in relevant industries or not). These groups were called objectives and are inspired by the patent measurement system of Yet2.com.

The result of the Wang & Hsieh (2015/3) model is the patent classification into three types: Class A (highly valuable), Class B (intermediate values), and Class C (low). After this classification, it is possible to establish strategic actions for patents. Two examples of decisions suggested in this model are 1) patents with very high scores (class A) the suggestions can be plans for licensing or for new venture initiatives; and 2) for patents with low scores in category C, auctioning or dropout are suggested because of the minimal patent-related opportunities.

Another model (Lee & Sohn. 2016), called 'Patent portfolio-based indicators to evaluate the commercial benefits of national plant genetic resources', is a patent evaluation framework based on the proposition of specific indicators that estimate the commercial value by the use of genetic resources in the biotechnology industry. Some indicators of this model have been established in terms of marketing (Impact Dimension - The diversity of related industry and nationality of inventors/applicants; Cost-Effectiveness Dimension - Patent family size, related industry scale and export; number of citations for forward and backward, Dimension Growth - Current impact, growth rate of patent applications and Dimension Exclusivity - Number of species of the same genus registered in Union for the Protection of New Varieties of Plants (PNVP). The result of this study is a map of value correlating the aspect of 'Technology' with that of 'Marketing' relative portfolio of Korean genetic resources that can help the State and users in the benefits-sharing agreements.

Considering that the model offers identification of the relative value rather than the exact monetary value of the patents, its leading contribution was to provide useful references for use as a reference point during the negotiation of benefit-sharing agreements (Lee & Sohn, 2016).

A detailed analysis of these models allows us to understand that they use some value indicators that do not always differentiate the value of patents produced by Science and Technology Institutions in contexts of developing economies such as Brazil, where patents have, for example, fewer cases of litigation, little interest in defending the market and reduced family size. A quick analysis using Orbit software shows that the number of international applications arriving in Latin American countries is much higher than those coming from here to the world, showing that patents in this region tend to have a small family (Orbit, 2019), moreover, the share of these international patents assigned to universities, institutes or individuals is small (Chakrabarti & Bhaumik, 2015). In this sense, this research aims to present a general model for patent evaluation that is useful for Brazilian Science and Technology Institutions, not excluding the possibility of application by institutions present in other Latin American countries with similar intellectual property generation dynamics (Fuquen & Escobar, 2018), as well as those who have, along with Brazil, Universities in the list of the top 500 in the world (*e.g.* Chile and Argentina) (Academic Ranking of World Universities, 2018).

Research Methodology

This research proposes to validate the leading indicators used in the patent evaluation to develop a framework for evaluating academic patent portfolios in Brazilian, through into three specific objectives:

Specific objective n.1: Map the existing patent portfolio evaluation models published in the ScienceDirect database (2009-2016), using terms related to assessment, assessment, value, valuation, evaluation or evaluation and patent or technologies with the following command 1: pub-date > 2009 and TITLE (assess* OR *valu* AND patent* OR technolog* AND portfolio). This command brought two important papers for the begging of this research because they presented relevant details and information to support the use of keywords to delimited the scope of the present research. They are 1) "The patent portfolio value analysis: A new framework to leverage patent information for strategic technology planning". (Grimaldi et al. 2018); and 2) "A framework for assessing a portfolio of technologies for licensing out" (Santiago et al. 2015). In command 2, excluded the term 'portfolio', obtaining a sample of 8 articles: (Van Wyk, 2010/4), (Wang et al., 2011), (Dunn, Luke, & Nassar, 2013/3), (Kontogianni, Tourkolias, & Skourtos, 2013/4), (Grimaldi et al., 2015/5), (Santiago et al., 2015), (Lee & Sohn, 2016) and (Song, Seol, & Park, 2016/2). The next search, command 3, taken out the exigency of the "portfolio" term. As the sample was extensive (1,780 articles), the search was limited by the topics "patent, technology assessment", obtaining, then, 85 articles. Afterward, these articles were classified in three ways: 1) Is it a patent portfolio assessment model with similar indicators to other models?; 2) Do you propose any of the leading evaluation indicators?; and, 3) Doesn't directly collaborate with the research objectives, but can be useful for methodology, method, analysis of results, others.

The specific objective n. 2: List the indicators most used in the models. After identifying similarities between 54 (fifty-four) indicators present in the models, these were grouped into a list of 18 (eighteen), they are: (1) Term of Patent Expires (Santiago et al., 2015); (2) Patent Family Size, or Geographical Scope of Protection (Grimaldi et al., 2015/5; Santiago et al., 2015; Suzuki, 2011/9); (3) Number of Claims (Grimaldi et al., 2015/5; Lee & Sohn, 2016; Suzuki, 2011/9; Wang & Hsieh, 2015/3); (4) Formal Limitations on Commercializing (Santiago et al., 2015); (5) Litigation (Hsieh, 2013/2); (6) Number of Citations (Grimaldi et al., 2015/5; Lee & Sohn, 2016; Suzuki, 2011/9); (7) Need of High Initial Investment (Hsieh, 2013/2; Santiago et al., 2015); (8) Need for certification and compliance with many standards (technological risk) (Hsieh, 2013/2); (9) Risk of market acceptance (Hsieh, 2013/2); (10) Market risk (eg changes in prices or market rates) (Hsieh, 2013/2); (11) Size of the market (Grimaldi et al., 2015/5; Santiago et al., 2015; Wang & Hsieh, 2015/3); (12) Economic relevance (Grimaldi et al., 2015/5); (13) Patent strategy (Grimaldi et al., 2015/5); (14) Impact of technology on industry (Level of innovation) (Santiago et al., 2015; Wang & Hsieh, 2015/3); (15) Superiority/competitiveness of technology in relation to substitutes (Santiago et al., 2015; Wang & Hsieh, 2015/3); (16) Market trend (Hsieh, 2013/2; Santiago et al., 2015); (17) Technology with the patent has already been licensed (Wang & Hsieh, 2015/3); (18) The technology has already been transformed into product or process (in start ups or spin-off) (Hsieh, 2013/2, Wang & Hsieh, 2015/3).

And, specific objective n.3: Validate the leading indicators for the evaluation of academic patents. The indicators were submitted to judgments according to their influence on the value of academic patents. Cronbach's Alpha was applied to guarantee the reliability of the data collection instrument (Maroco & Garcia-Marques, 2013). The result obtained was 0,789, which indicates reasonable reliability between 0,7 and 0,8. We used the Exploratory Factor Analysis method of the 18 criteria, with the student version of the Statistical Package for the Social Sciences (SPSS) software, obtaining 7 (seven) main components (Hair, Black, Babin, Anderson, & Tatham, 2009; Saunders, Lewis, & Thornhill, 2007).

After finding these 7 (seven) possible factors, the next step was to find the relevance of each on the market value of patents in Brazil. Wang et al., (2011) used weights obtained quantitatively by mathematical, statistical, and computational equations. Other authors determined these weights by interviews using questionnaire research with experts (Hsieh, 2013/2; Lee & Sohn, 2016; B. Wang & Hsieh, 2015/3). This research obtained the weights using the Analytical Hierarchical Process' method. AHP is a method of solving a problem with multi-criteria with qualitative and quantitative characteristics (Saaty, 1990). Since subcriteria are structured hierarchically, decision-makers assign a level of importance to each criterion through comparisons of pairs to produce scores, which are the weights for the indicators.

Sample definition and data collection

Brazil is the Latin American country with the most Universities in the top 500 ranking of 2018 (Academic Ranking of World Universities, 2018), two of which - the University of São Paulo and University of Campinas - are among the most respected universities in Latin America by managing the Technology Transferences process through their Technologies Transferences Officers (Dias & Porto, 2018). Given the similarities in the dynamics of intellectual property generation with other Latin American countries (Fuquen & Escobar, 2018), consulting experts from the higher-yielding Brazilian science and technology institutions means, to some extent, capturing the expertise of capable professionals reflect the similar and positive characteristics of Latin American innovation systems (Lee & Kim, 2018), as well as their patterns of technological expertise (less dynamic and stagnant technologies) over the last decades compared to other emerging economies such as Asia (Urraca-Ruiz, 2019).

The sample of experts consulted in this research was composed of 39 professionals, among managers of technology transfer offices or experts on this subject. To reach this number, a form with questions was sent to the estimated population of this sample, for a total of 428 (four hundred and twenty-eight) people. This was done through contact with Intellectual Property Associations in Brazil: Academic Association of Intellectual Property (AIP) of the State of Sergipe, Intellectual Property Association of São Paulo (IPASP), Brazilian Association of Intellectual Property Agents (BAIPA), National Association of Research and Development of Innovative Companies (NARDIC) Brazilian Intellectual Property Association (BIPA), Postgraduate Program in Intellectual Property (PPIP) of the Federal University of Sergipe (FUS), PROFINIT Program, and professionals from Centers of Technological Innovation of Science and Technology Institutions (public or private). In this step, the percentage of responses was only 9.13%. To reach the specific objective 3 (validation of the indicators), the second collection (Step 2) was carried out with a focus group using another questionnaire. There were 23 respondents in this 2nd step.

A limitation regarding the selection of the sample of this research is the number of respondents of step 1 that, according to Hair et al., (2009), preferably a factorial analysis is performed with a sample greater than or equal to 100 and, as a general rule, the minimum is to have at least five times more observations than the number of variables to be analyzed, conditions that are not respected by the sample of the present study, so that the Exploratory Factor Analysis performed is indicative of possible factors.

Results and discussion

Step 1 of the research: focus group consultation and factorial analysis

In order to identify the leading determinant factors to the evaluation of academic patents, an Exploratory Factorial Analysis was applied on 18 (eighteen) indicators most commonly used in models to evaluation patents. The Kaiser-Meyer-Olkin (KMO) and Bartlett tests are found to be 0,563 an less than 0,001, respectively. These results show that the Factorial Analysis is useful, allowing reject the hypothesis of the identity of the correlation matrix, i.e., that the variables are correlated to the level of significance of 5%. So, it is possible to proceed with the Factorial Analysis. After analyzing all the assumptions for the application of the factor analysis, it is observed that some variables have values of sample adequacy below 0.5, however, as the communities after extraction have values higher than 0.5, if not remove them. For the extraction of the factors, the principal components method was chosen. To identify the number of factors, the Kaiser and Pearson criteria were applied, resulting in 7 factors with their own values greater than 1 (one) and a variance cumulative percentage of 71.06% in the total variance.

In order to facilitate the interpretation of the factors, a factor rotation was performed according to the Varimax method to maximize the values of the factorial loads so that each variable is associated to only one factor. Table 1 shows that Factor 1 brought together the indicators Litigation, Market Risk, Patent Licensed Technology and Technology Transformed into Product explains 24.07% of the total variance, thus being the most important factor. The other factors explain, respectively: Factor 2 explains 12.37% of the total variance; Factor 3 explains 10.33%; Factor 4 explains 9.94%; Factor 5 explains 7.86%; Factor 6 explains 6.31%; and finally, Factor 7 explains 5.48% of the total variance.

In table 1 it's possible to visualize the results of Step 1: Focus group consultation and factorial analysis.

Table 1. Summary of Exploratory Factor Analysis for patent assessment criteria

Factors (Patents Assessment Criteria)	Factorial load	% of variance explained	Values	Communalities after extraction
Factor 1		24,077	4,575	
Technology transformed into Product	0,778			0,842
Market Risk	0,688			0,705
Technology licensed with the patent	0,673			0,576
Litigation	0,628			0,734
Factor 2		12,378	2,352	
Economic Relevance	0,809			0,729
Market Size	0,656			0,605
Patent Strategy	0,593			0,762
Factor 3		10,335	1,964	
Impact of Technology on Industry	0,889			0,869
Superiority / Substitutes	0,765			0,746
Number of Claims	0,531			0,710
Factor 4		9,942	1,889	
Formal Marketing Limitations	0,674			0,778
Size of the Patent Family (Geographic Scope of Protection)	0,851			0,770
Factor 5		7,869	1,495	
Need for High Initial Investment	0,908			0,876
Need for certifications	0,840			0,888
Market Acceptance Risk	0,292			0,677
Factor 6		6,317	1,200	
Number of citations	0,735			0,760
Market Trends	0,584			0,798
Factor 7		5,481	1,041	
The term of patent expires	0,869			0,838

Looking at Table 1, some highlights deserve attention. Litigation presented the lowest factor load in the 'Factor 1' group, indicating that it is not a relevant criterion to determine the value of patents in Brazil, unlike studies in other markets (Agliardi & Agliardi, 2011, Allison, Lemley, Moore, & Derek Trunkey , 2003; Hsieh, 2013/2, Zhang, Lv, & Zhou, 2014/3). The explanation can be the shortage of legal processes involving academic patents in Brazil.

'Patenting Strategy' is a factor-only support criterion, unlike other studies (Grimaldi et al., 2015/5; Suzuki, 2011/9) that have a prominence in the value of the patent when they have the potential to block. This result is justified by the inherent characteristics of the academic patents since they come from research without interest to defend some market dominated by technology, as it happens in private companies of high technological intensity.

'Number of claims' had the lowest factor load factor 3, demonstrating only to be a criterion supporting factor 3. This result differs from other studies (Grimaldi et al., 2015/5; Lee & Sohn, 2016; Suzuki, 2011/9 (Wang et al., 2011). Perhaps if the term presented to the experts was 'Quality of claims' (Wang Wang & Hsieh, 2015/3), the result could be different.

The lowest factor load was 'Market Acceptance Risk' (0.292). The explanation may be related to the profile of academic patents that are, in general, embryonic (Jerry G. Thursby, Jensen, & Thursby, 2001) and more process-focused than products. And when related to products, it generally has no potential to create new markets and therefore the experts consulted do not come with this criterion with a strong relation to the value of patents in the context of Brazil' ICT.

Finally, another highlight was the 'Number of citations' (forward and backward) criterion that has a high factorial load, indicating that it is relevant to determine the value of patents in Brazil, confirming most of the international studies related to this criterion (Grimaldi et al. al., 2015/5, Lee & Sohn, 2016, Suzuki, 2011/9).

Factors have been renamed and their definitions are presented in Table 2:

Table 2. Factors renamed from the factorial load of the independent criteria

Factors renamed	Independent criteria / Factorial load
Factor 1 – 'Expectations regarding the level of technological maturity'	Technology Transformed into Product: 0,778; Technology Licensed with Patent: 0,673; Market Risk: 0,688; and Litigation: 0.628
Factor 2 - 'Expectations regarding the financial return of the investment'	Economic Relevance: 0,809; Market Size: 0.656; and Patenting Strategy: 0.593
Factor 3 - 'Expectations regarding the competitive advantage of technology in its segment and its superiority over substitutes'	Impact of Technology on Industry: 0,889; Superiority in relation to Substitutes: 0.765; and Number of Claims: 0.531
Factor 4 - 'Expectations regarding the Patent Family Size'	Size of the Patent Family (Geographic Protection Range): 0.851; and Formal marketing restrictions: 0,674
Factor 5 - 'Expectations regarding the high initial investments to start production and meet certification requirements'	Need for High Initial Investment: 0.908; Requirement of Certifications: 0,840; Market Acceptance Risk: 0.292.
Factor 6 – 'Expectations regarding the patent quality in terms of citations'	Number of Citations: 0.735; Market Trend: 0.584
Factor 7 – 'Expectations regarding the remaining time of the patent '	Deadline for the Patent Expires: 0.899

According to Table 2, the proposed definitions for the factors after factorial rotation are:

Factor 1: Considering that the variables with the highest factor load were 'Technology Transformed into Product' (0,778) - related to the distance (or time) necessary for the technology to be ready for commercial application (Jerry G. Thursby et al., 2001) - this factor was renamed as 'Expectations regarding the status of technological maturity'. In this context, the other variables are support for this factor, especially when a patent is already licensed, since it indicates a higher level of maturity (J. G. Thursby & Thursby, 2007) and interaction with industry (Pojo, 2014); or when a patent is in the process of litigation, since it indicates greater value perceived by the litigants (Allison et al., 2003).

Factor 2: Considering that the variables with the highest factor load were 'Economic Relevance' (0.809) - which represents the sales of the patent in relation to the entire portfolio - and 'Size of the Market' (0.656) - which represents the expectation of sales -, this factor was renamed as 'Expectations regarding the financial return on the investment'. In this context, the other variable, 'Patenting Strategy', that indicates whether the patent has the function of conquering new markets and/or defending an organization's existing market (Grimaldi et al., 2015/5), function as support for increased sales expectations.

Factor 3: Considering that the variables with the greatest factorial load were 'Impact of Technology in Industry' (0,889) - which represents the level of technology innovation, that is, how strong is its competitive advantage in the segment - and 'Superiority in Relation to Substitutes' (Santiago et al., 2015; B. Wang & Hsieh, 2015/3), this factor was renamed as 'Expectations regarding the competitive advantage of technology in its segment and its superiority in relation to substitutes'. In this context, the variable 'Number of Claims' is support to increase sales expectations, as the claims reflect the technological importance of innovation and the number of claims shows that innovation has a potential for profitability embodied in it (Grimaldi et al., 2015/5).

Factor 4: Considering that the variable with the highest factorial load was 'Patent Family Size' (0.851) - which indicates the number and types of countries/jurisdictions where the patent is protected (Fischer & Leidinger, 2014/4; Grimaldi et al., 2015/5) - this factor was renamed as 'Expectations regarding the Patent Family Size'. In this context, the other variable, 'Formal Marketing Restrictions" is a limiting factor (Santiago et al., 2015).

Factor 5: Considering that the variables with the greatest factorial load were 'Need for High Initial Investment' (0.908) and 'Need for Certifications' (0.840) - bottlenecks that reduce the commercial potential of the patent (Santiago et al., 2015) - this factor was renamed 'Expectations regarding the high initial investments to start production and attend certification requirements'. In this context, the other variable, 'Market Acceptance Risk', acts as a support to factor, since the greater the Market Acceptance Risk' (eg technology without a defined market) the greater the investment to decrease this risk (Ferreira, 2013).

Factor 6: Considering that the variables with the highest factor load were 'Number of Citations' contained in the patent (Tantiyaswasdikul, 2014) or received by other patents (Chen & Chang, 2009), this factor was renamed as 'Expectations regarding the quality of patent in terms of citations (back and forth)'. In addition, the Patent Citation variable is one of the 13 variables used in the trend analysis method of (Gao et al., 2013/3) and helps to estimate the future development of a technology from the technological life cycle, according to the identification of the emergent phases, growth, maturity, and saturation of the technology. For this reason, the other variable - 'Market Trend' - functions as a support for this factor.

Factor 7: This factor includes a question related to the marketing limiter that is the remaining time of exploitation, being critical for patents with less than 5 years to expire (Santiago et al., 2015). For this reason, this has been renamed as 'Expectations regarding the remaining time of the patent'

The factors described in Table 2 were then grouped into a hierarchy with two sets (Technology x Market). For Wang et al., (2011), the analysis of the Science and Technology Institutions Portfolio for commercialization purposes is a problem of multiple criteria distributed in a hierarchical structure that can present by qualitative or quantitative characteristics. For this reason, the following item brings the analysis of the data through the Analytical Hierarchy Process (AHP).

Step 2 of the research - Analytical Hierarchy Process (AHP)

Determining a precise method for estimating the value of the patent is like a "Holy Grail" within patent studies and practices. "Several of the proposed approaches generally fall into one of two categories: (1) methods of financial assessment, or (2) non-financial valuation methods" (Torrance & West., 2017, p. 472). The variables are grouped into 'technological value' and 'business value' (Liu et al., 2014) and it's indicates that for the analysis it needs a method for problems with multi-criteria. Considering that the Analytical Hierarchy Process (AHP) is a method of solving a problem with multicriteria containing qualitative and quantitative characteristics (Saaty, 1990), the paired comparison of the factors in Step 1 generated the matrices in the graph of figure 1.

Figure 1. Matrices after peer comparison and ranking of relevance

Matrix - Technology dimension

Matrix		Fator 1 1	Fator 3 2	Fator 6 3	0 4	0 5	0 6	0 7	0 8	0 9	0 10	normalized principal Eigenvector
Fator 1	1	-	3/8	2 1/3	-	-	-	-	-	-	-	25,34%
Fator 3	2	2 2/3	-	5	-	-	-	-	-	-	-	62,88%
Fator 6	3	3/7	1/5	-	-	-	-	-	-	-	-	11,77%
0	4	-	-	-	-	-	-	-	-	-	-	0,00%
0	5	-	-	-	-	-	-	-	-	-	-	0,00%
0	6	-	-	-	-	-	-	-	-	-	-	0,00%
0	7	-	-	-	-	-	-	-	-	-	-	0,00%
0	8	-	-	-	-	-	-	-	-	-	-	0,00%
0	9	-	-	-	-	-	-	-	-	-	-	0,00%
0	10	-	-	-	-	-	-	-	-	-	-	0,00%

Matrix - Market dimension

Matrix		Fator 2 1	Fator 4 2	Fator 5 3	Fator 7 4	0 5	0 6	0 7	0 8	0 9	0 10	normalized principal Eigenvector
Fator 2	1	-	5 4/5	1 2/5	2 1/2	-	-	-	-	-	-	42,69%
Fator 4	2	1/6	-	1/5	2/7	-	-	-	-	-	-	6,44%
Fator 5	3	5/7	4 2/3	-	1 8/9	-	-	-	-	-	-	32,02%
Fator 7	4	2/5	3 3/5	1/2	-	-	-	-	-	-	-	18,86%
0	5	-	-	-	-	-	-	-	-	-	-	0,00%
0	6	-	-	-	-	-	-	-	-	-	-	0,00%
0	7	-	-	-	-	-	-	-	-	-	-	0,00%
0	8	-	-	-	-	-	-	-	-	-	-	0,00%
0	9	-	-	-	-	-	-	-	-	-	-	0,00%
0	10	-	-	-	-	-	-	-	-	-	-	0,00%

Adapted of Goepel (2013)

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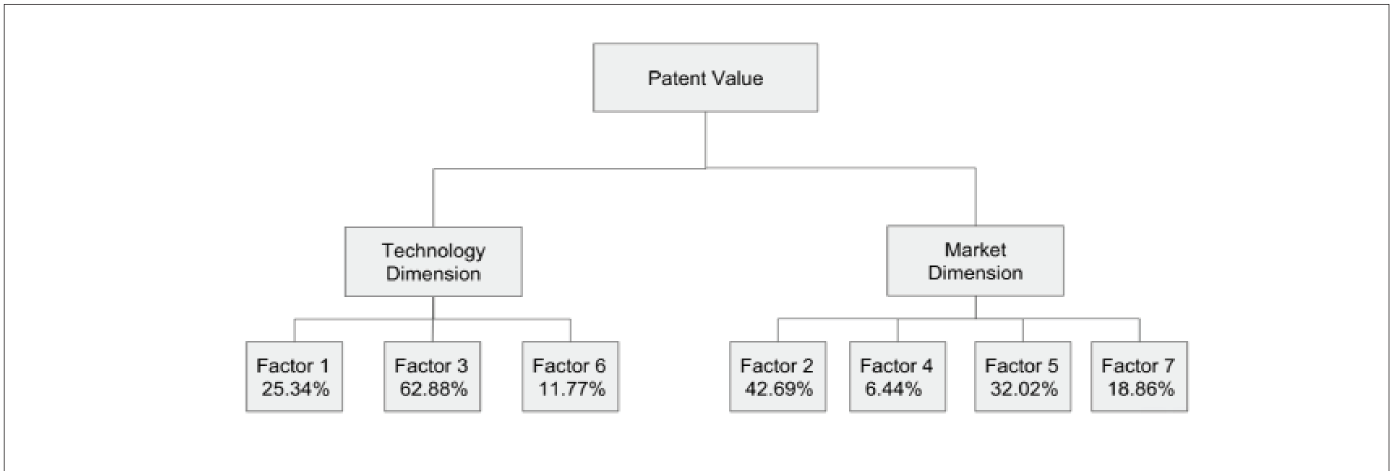
The Figure 1 (left side) shows that, after adding all the comparisons in pairs (Factor 1 x Factor 3, Factor 1 x Factor 6, Factor 6 x Factor 3) of all specialists, the result was that Factor 1 has a weight of 25.34%, Factor 3 has a weight of 62.88% and Factor 6 has a weight of 11.77%.

This means that among the factor from the technology dimension that more interfere in the value of a patent, Factor 3 is the strongest.

By adding all the comparisons in pairs (Factor 2 x Factor 4, Factor 2 x Factor 5, Factor 2 x Factor 7, Factor 4 x Factor 5, Factor 4 x Factor 7, Factor 5 x Factor 7) from responses of all the specialists, the result was that Factor 2 has a weight of 42.69%, Factor 4 has a weight of 6.44%, Factor 5 has a weight of 32.02%, Factor 7 has a weight of 18,86%. This means that among the factor from the marketing dimension that interferes in the value of a patent, Factor 2 is the strongest. The hierarchy of all the criteria and their weights that could be made with the technology and market dimension are expressed in figure 2.

Figure. 2. Hierarchy of all the criteria and their weights



Subtitle:
Factor 1: Expectations regarding the level of technological maturity.
Factor 3: Expectations regarding the competitive advantage of technology in its segment and its superiority in relation to substitutes.
Factor 6: Expectations regarding patent quality in terms of citations (back and forward).
Factor 2: Expectations regarding the financial return on the investment.
Factor 4: Expectations regarding the patent family size.
Factor 5: Expectations regarding the high initial investments to start production and meet certification requirements.
Factor 7: Expectations regarding the remaining time spent on the patent

In Technology Dimension (Figure 2), factor 3 - Expectations regarding the competitive advantage of technology in its segment and its superiority in relation to substitutes - is highlighted with 62.88%. This result proves that the power to generate technological advances, and consequently technological leadership in a given segment or in several segments, is strongly related to the potential of greater financial returns to academic patent in Brazilian context, confirming indicators of other studies (Santiago et al. al., 2015, Wang and Hsieh 2015).

Technological maturity (Factor 1) is the second most influential in patent value with 25.34%. Considering that this factor is related to the time required for the technology to be ready for commercialization, involving proof of concept, laboratory-scale prototype, and proven manufacturing (Thursby; Jensen; Thursby, 2001), the explanation can be found in the study of Liu, Cao and Song (2014) that analyzed the motivation of the academic inventor/researcher and proved that it, in general, is to satisfy the academic performance, explaining, thus, both the factor influence in Brazilian context as the presence of it among all the indicators of technology already confirmed in the literature.

In the third position is 'Expectations regarding patent quality in terms of citations' (Factor 6). Despite of many studies support the positive influence this factor on patent value (Tantiyaswasdikul, 2014; Grimaldi, Cricelli, Di Giovanni, & Rogo, 2015/5; Hsieh, 2013/2; Lee & Sohn, 2016; Suzuki, 2011/9; Harhoff, Scherer, & Vopel, 2003; Chen & Chang, 2009; Wang, García, Guijarro, & Moya, 2011) it has to observed in context of patent technological life cycle (Gao et al., 2013/3) and considering that the number of citations is strictly dependent on the patent age (citation lag) (Grimaldi et al., 2015/5), it can explain the 3 third position in the technology dimension.

Yet, given the Market Dimension, "Expectations regarding the financial return on investment" (Factor 2) stand out as more relevant (approximately 43%). This factor has a different combination of indicators obtained by Lee and Sohn (2016) in rentability dimension, and different from (Grimaldi et al (2015), Wang & Hsieh (2015), but this is not a question of a current financial return, but of the expectation of return, since Brazilian academic patents are not generating financial resources, mostly. The influence in the value is explained because one of the main interests of investors, that is, how much they can bill with the commercialization of new technology or product. The "Expectations for high initial investments to start production and meet certification requirements" (Factor 5) correspond to the second most relevant factor in the market dimension. This result is expected, as it corresponds to the following questioning of the majority investors regarding the market dimension, since the initial costs necessary for such marketing may represent a high risk.

The presence of factor 4 (Expectations regarding the size of the patent family) demonstrates its importance in patent value studies, but its low percentage relative to the other market dimension factors shows the need for its adjustment within the Brazilian and Latin American context. It is understood that this value indicator may be very relevant in other patent value models developed in more advanced markets (Grimaldi et al., 2015; Lee & Sohn, 2016), but it is of little relevance to separate valuable and non-patent patents of academic patents from Brazil or other Latin American countries with economic similarities.

It stands out that figure 2 shows a consensus on the most relevant criteria for evaluating academic patents in a Brazilian context. Despite the experience or knowledge of these professionals, their judgments may be inconsistent), that is why the AHP that uses the Consistency Indicator (CI) to measure these discrepancies and the adequate tolerance of these inconsistencies (Wang & Hsieh, 2015/3). The Consistency Indicator (CI) of the responses regarding the technology dimension factors was 0.5%, with the limit being 5% for matrices with 3 factors - and to factors of the market dimension was 0.8% - is that the limit is 9% for matrices with 4 factors, thus, the CI of the 2 factors of the model is consistent.

The worksheet used to generate these results (Goepel, 2013) is limited to 20 judgments, so when this number was reached, some judgments were withdrawn and/or replaced, according to the degree of inconsistencies above the limits suggested by the AHP method, when isolated.

The calculation of the CI for each judgment separately is given by the equation:

CI (Consistency Index) =

$\frac{nMax-n}{n-1}$, where $nMax = \left[\sum_{L=1}^{n} \square \sum_{j=1}^{n} \square \,(aL,j\,.Weight\ Lj) - n\right] / (n-1)$ and n =

The general result shows consistency with respect to the general order of importance for each group of factors involved (Saaty, 1990) since the consensus among the specialists was as follows: 75.6% for factors of the technology dimension and 77.4% for factors of the market dimension (Goepel, 2013).

Final considerations

This study used a review of the existing literature to identify 18 criteria (indicators) that may influence the value of academic patents. These criteria were subject to expert judgment when the influence of each on the market value of academic patents (Step 1). The reliability of the data was obtained using Cronbach's Alpha.

From the results of this first step 1, seven factors were extracted by exploratory factorial analysis and separated between factors of technology and market factors, similar to previous studies (Santiago et al., 2015). The Technology group brought together three factors and the 'Market group brought together four factors forming a hierarchy. In the second step of the research, a peer evaluation was made of each factor (technology factors with technology factors and market factors with market factors). For this, the AHP was used (a method to solve a problem with multiple criteria) and thus to define the relative importance (the weights) of each criterion to reveal the market potential of academic patents.

The prior analysis of a qualitative perspective that separates the most relevant patents within a portfolio facilitates the valuation process, although criticisms could be made to this research, concerning the criteria and the sample. One advantage of this study is that it considers the perspectives of several Technology Transfer (TT) experts, offering a consensus on the most relevant criteria to an assessment of the patent. An important contribution is a fact that these criteria are refined by adjusting value indicators that in the other developed models (*e.g.* Asia and Europe) has more relevance, but may not be useful in separating valuable and non-valuable patents in a portfolio of academic patents from Brazil or other Latin American countries.

For the decision-makers, the results of this study have positive implications for the management of Intellectual Property, since Technology Transfer Managers in Brazil can use the 7 factors and their weights identified - based on the existing literature, as well as the opinion of focus groups patents - to evaluate (identify) patents from the portfolios of Science and Technology Institutions (STI) with greater market potential. In addition, decision-makers form these Institutions through their patent application evaluation boards - can judge whether or not it is strategic to promote a patent application by their researchers internally. In this way, instruments for evaluating new applications for patents in research and innovation institutions could be improved based on these factors. Its usefulness would even reach the analysis of research projects for financing purposes, allowing, in a context of scarce resources in the Science and Technology Institutions, to invest in projects with the potential to generate more valuable patents.

Specific technology transfer strategic plans can be designed and structured using the results of this study. For example, a marketing plan may use the most relevant market factors and technology factors to better expose the patent to potential customers. Market and technology potential assessment software can be developed to help low-income Science and Technology Institutions to separate potential return patents for institutions that have invested so many resources in their lab and researchers throughout the development of their inventions.

For future studies, it is suggested to confirm the factors through a Confirmatory Factor Analysis in Brazil and Latin American countries, with Science and Technology Institutions with similar patent productivity. Also, it is suggested to develop a Structural Equation Model that can serve as a general parameter for Academic Patent Portfolio Assessments in the same context as this research.

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The Knowledge Body of Requirement Engineering in IST Innovations: An Ontological Analysis

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Abstract: Requirement Engineering is considered a key factor for Information Systems and Technology (IST) success in innovation. After roughly 40 years, important questions about the impact of RE in innovations remains. Literature review and bibliometric reports are well-known techniques for describing the state of the art; however, both can cover what has been done, but fail to identify the less developed areas. An alternative method is used to describe the whole knowledge body of RE (KBoRE) for IST innovations, and then systematically identify the most, less and uncovered areas. This paper proposes an Ontological framework of the KBoRE for IST innovations, by decomposing it through the identification of taxonomies and concepts that represent the field. Then, we apply the ontology to map articles from SCOPUS and WoS databases. Results reveal emphases that help to design research agendas and feed the KBoRE for IST Innovations to fill the gaps between the academic curiosity and the industry progress.

Keywords: Requirement Engineering; Ontological Analysis; Digital Transformation; Innovation; Information System

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Introduction

Requirements Engineering (RE), is a discipline focused on the elicitation, analysis, negotiation, documentation, validation, and verification of software requirements, and is considered a key factor for the success of Information System and Technology projects (IST) (Cheng & Atlee, 2007; Daneva, Damian, Marchetto, & Pastor, 2014). A proper execution of RE might identify and prioritize the stakeholders' needs, improve value communication, reduce misunderstandings between developers and users, help to manage the scope of projects, facilitate testing with business rules and seize the efforts necessary to develop IST, and overall, increase the probability of project success (Cheng & Atlee, 2007; Nuseibeh & Easterbrook, 2000; Parnas, 1999). Such an ambitious list of objectives expands as the use and pervasiveness of IST also reach almost all corners of society (Ruhe et al 2017) implying an increasing variety of users and purposes.

The growing interest in the academic community is evidenced in the growing number of scientific publications. A bibliometric description shows that between the end of the 1980s and the year 2017, the number of publications indexed by the Web of Science increased from 3 per year to more than 350 annually; similar trend is observed analyzing the citations to the published research, where for the year 2017 it was computed in more than 8,000 citations. Furthermore, the establishment of important conferences - such as RE, REFSQ, and EmpiRE- and scientific journals focused on RE, such as the Requirements Engineering Journal, demonstrates an ongoing maturity process in the discipline. This development has produced a number of tools, methods, and approaches such as Volere (Robertson & Robertson, 2000), EARS, and UML-based tools, some of them are still in use and others have been replaced by novel and more effective solutions. Such variety is huge and dynamic as new instruments are being created, implemented, and tested periodically (Moira, 2016).

Nowadays, every organization is immersed in the changes of their environment, such us the full digitalization of companies, requiring complete redesign of their products, services, business processes, and other areas in the organization that is considered as Digital Transformation. These changes are affecting companies and they must properly react to the new directions imposed by factors that make their surroundings more dynamic, complex, and competitive. Organizations need to foresee the coming transformations, either by internal or external factors or detect them in case they missed them and then boost a new manner to do business (Porter, 1998). This 'new manner' can be considered as the 'innovation' phenomenon, and according to literature, it has been widely studied from different research approaches (Edquist, 1996; Geldes, Felzensztein, & Palacios-Fenech, 2017; Heredia Pérez, Geldes, Kunc, & Flores, 2019; Pyka, 2002), methods and classifications in order to understand it (Gunday, Ulusoy, Kilic, & Alpkan, 2011; Oke, 2007; Subramanian & Nilakanta, 1996). Some definitions in business contexts label innovations as 'business process reengineering" (Hammer & Champy, 2009), 'revolutionary change' (Ramaprasad, 1982), 'disruptive change' (Christensen & Overdorf, 2000), or 'creative destruction' (Schumpeter, 1942), and the IST development is at the same time affected and an influencer of this phenomena, by the initiatives of the stakeholders that seek to satisfy their business needs with the aid of IST solutions such as digital transformations, process automation and digitalization. In this context, the RE might contribute to the innovation process success, functioning as a bridge between the stakeholders' needs and the final information systems products and services.

In spite of the increasing variety of instruments for RE, the rate of success of IST projects is low and the research gap on the impact of RE for IST innovation is large, considering the importance of the RE in the development of information systems and technologies (Baculard, Colombani, Flam, Lancry & Spaulding, 2017; Remes, Manyika,

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Bughin, Woetzel, Mischke, & Krishnan, 2018; Walker, 2017). After roughly 40 years of progress in RE research, important questions remain unsolved about the state of the discipline and where it should further develop to impact the practice in IST, especially in the context of digital transformations and disruptive change (Yin and Pfahl 2017; Cleland-Huang 2018). This article presents an alternative method to: (1) systemically describe the whole Knowledge Body of RE for IST innovations, (2) systematically identify the emphases and gaps in RE to revise and strategically propose research agendas that enhance the use of RE methods, tools and techniques in revolutionary IST projects. The method applied in this study – an ontological analysis – decomposed the KBoRE for IST innovations as a composition of taxonomies based on the RE body of knowledge. Then, the ontological framework is used to systematically map all the articles with the titles, abstracts, and keywords about RE and innovation in IST queried from SCOPUS and WoS databases, allowing us to identify the bright and blind/blank documented knowledge for the development of RE in IST innovations.

Related Works

The development of a discipline is a complex and diffuse process, without guidelines or agenda. In this context, the literature review (LR) seeks to systematize the description of this process. Without a clear image of the discipline, one face the risk of observing only a part of the whole, which would consequently generate a biased lens to address the entire problem systemically (Ramaprasad & Syn, 2015). LR of RE have analyzed the main trends in the discipline but fail in detecting themes with lesser development or needed by industries leaving important questions unanswered regarding the fit and selection of RE tools and methods for an appropriate specification in the digital innovations and revolution scene brought by the IST innovations.

An analysis of the literature in RE illustrates the growth of the discipline and describes the current emphases. For example, Nuseibeh and Easterbrook (2000) systematically reviewed the publications between 1990 and 2000 to describe the maturity reached in RE as one that allowed the development of workshops and academic meetings by the end of the '90 decade; also, the authors identify the need for the creation of new RE techniques. Later, Cheng & Atlee (Cheng & Atlee, 2007) updated the literature review of (Nuseibeh & Easterbrook, 2000), identifying the creation of new tools and the need for strengthening the *researcher-practitioner relationship*. More recently, Matyokurehwa, Mavetera and Jokonya (2010) considered a time window from 2000 to 2016 for a literature review, evidencing a great variety of methods and techniques, however, none of the these consider the whole RE process systemically and holistically, leaving for the practitioner the task to choose tools for RE implementation from a wide and dynamic variety in the software market. It should be noted that, given the recent but dynamic, rapid and complex growth of RE, researchers have focused their studies in certain aspects, such as the use of techniques in agile development methodologies (Zamudio, Aguilar, Tripp, & Misra, 2017) or the use of empirical RE techniques (Ambreen, Ikram, Usman, & Niazi, 2018) either by their importance or urgency, or as a herd effect of what is being published in academic journals.

In the literature, it is found that just a few scholars have done research about RE and IST innovations. For example, Kauppinen, Savolainen, & Mannisto (2007) observed RE activities in six Finnish companies and identified the vital role that RE plays in the innovative process of an IST development. According to their analysis, three main opportunities arise for RE in innovation: 1) discovering hidden customer and user needs, 2) inventing new product features that satisfy these needs, and 3) supporting feature development with an innovative technical solution. More recently, Munir, Wnuk, & Runeson (2016) published a systematic review of Open Innovation (OI) in software engineering, where one of their three search string strategies included the 'requirement*' and 'engineer*' keywords. The analysis of the sample showed that OI provided access to a wide and heterogeneous sample of stakeholders, claiming for the use of techniques that allow the identification of the key groups of stakeholders and their understanding; hence, the call for methods that may better satisfy this need.

In the context of missing systemic guidelines, a methodology that makes visible the whole and permits the systematic identification of the main emphases already documented in the literature, as well as its gaps, is considered as an attractive alternative. The ontological frameworks allow the identification and description of the whole, giving way to the systematic mapping of the literature (Ramaprasad & Syn, 2015). The ontology allows, first, to identify all the parts of Body of Knowledge of Requirement Engineering (KBoRE) for IST innovations, and second, the visualization of the areas that have been widely documented (bright areas of knowledge) and those that have been so far reduced or ignored (blind/blank areas of knowledge). The versatility of the ontological analyses is demonstrated by its use in various disciplines and areas, such as information systems (La Paz, Merigó, Powell, Ramaprasad, & Syn, 2019) (Manzano, Ramaprasad, & Syn, 2018), e-commerce (La Paz, Ramaprasad, Syn, & Vasquez, 2015), healthcare management (Núñez, Neriz, Mateo, Ramis, & Ramaprasad, 2018; Ramaprasad & Syn, 2015; Ramaprasad, Win, Syn, Beydoun, & Dawson, 2016) , culture (Yaco & Ramaprasad, 2018), education (La Paz & Arrúa, 2019) (Coronado, La Paz, Ramaprasad, & Syn, 2015) and sustainable growth (Cancino, La Paz, Ramaprasad, & Syn, 2018).

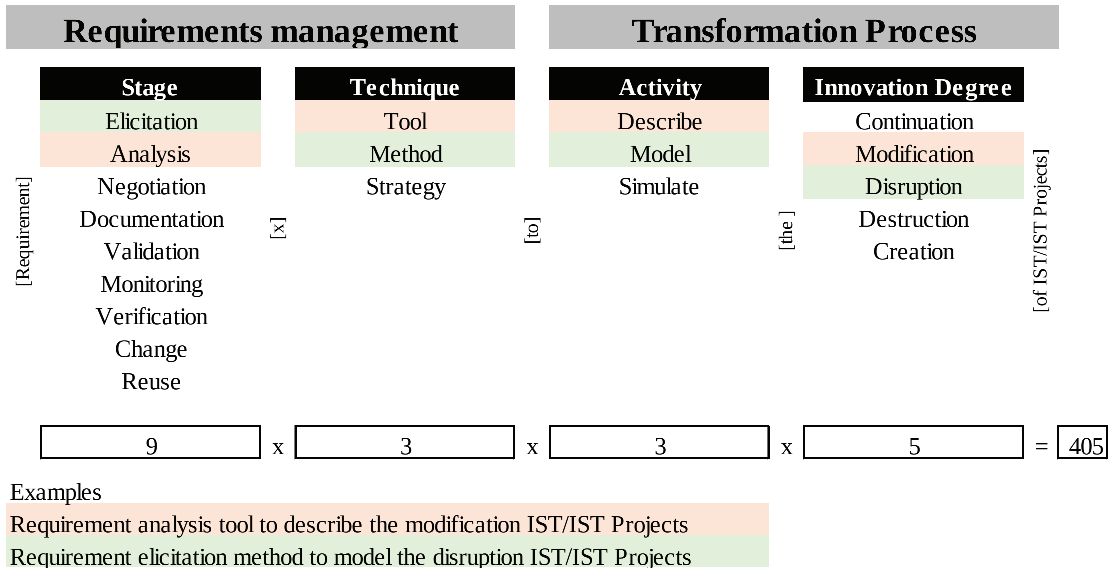
Building and Validating the KBoRE for IST Innovations Ontology

Building the Ontology

Ontologies focus on the nature and structure of things, independent of any other consideration and even independent from their real existence (Guarino, Oberle, & Staab, 2009; Ramaprasad & Syn, 2015). We built an ontology to represent and analyze the KBoRE for ISTi by deconstructing the complexity of the discipline considering two sub-ontologies that represent the *Requirement Managemen*t and *the Innovation Process*. The KBoRE for ISTi Ontology is represented by an ordered combination of these sub-ontologies, composed themselves by representative and well-known concepts in RE and *innovation processes* presented in taxonomies. The final taxonomies and elements grouped in the RE subontology were defined after the analysis of articles in the literature, and in the case of the innovation process sub-ontology, the Global Innovation Index (GII) framework was considered.

After a comprehensive analysis of literature and the GII framework, we defined the next two sub-ontologies and elements. The sub-ontology of *Requirements Management* is composed by two taxonomies: (1) Stage and (2) Technique, and the *Innovation Process* sub-ontology includes: (1) Activity and (2) Innovation Degree. The Figure 1 introduces the KBoRE for IST innovations Ontology, which contains a total of 405 themes/areas of the RE in Digital Transformation contexts, calculated as all the possible combinations of the elements from taxonomies. To illustrate one use of the ontology, two themes have been colored in the figure, and presented here as texts: (1) Requirement analysis tool to describe the modification of IST/IST Projects, and (2) Requirement elicitation method to model the disruption of IST/IST Projects.

Figure 1. KBoRE for ISTiKB Ontology composed by the two ordered sub-ontologies.



Validating the Ontology

A mapping procedure of a sample of articles onto the ontology was implemented as a validation process. The results would allow acquiring the sense of how well the ontology performs as a framework, as well as to identify the bright and blind spots of the sample. The latter may support conclusions about what has been done in RE and IST innovations and which areas could be interesting to research in the future and the present empirical study. The validation procedure is explained in the following paragraph and the results and discussed in the next section.

We retrieved the title, abstract and keywords of articles related to the following research queries from the SCOPUS and WoS databases, which contains Spanish and English words for capturing Latin America (LATAM) articles

SCOPUS: (TITLE-ABS-KEY(“requirement engineering” OR “requirements engineering” OR “ingenieria de requerimientos” OR “ingeniería de requerimientos”) AND TITLE-ABS-KEY(innovat* OR innov*))

WoS: TODOS LOS CAMPOS: (“requirement engineering” OR “requirements engineering” OR “ingenieria de requerimientos” OR “ingeniería de requerimientos”) AND TODOS LOS CAMPOS: (innovat* OR innov*) Período de tiempo: Todos los años. Índices: SCI-EXPANDED, SSCI, A&HCI, ESCI.

The queries provided a total of 587 records. An analysis of articles related to LATAM, indicated that less than 4% were related to countries in Latin America (17 from Scopus and 4 from WoS). These results highlight a symptom of the problem related to the small efforts and resources that these countries invest in the innovation, and more specifically, about the relationship between RE and IST projects. Testing the ontology with this dataset does not allows us to obtain robust conclusions, however, the authors decided to use the entire sample in order to validate the ontology and provide future insights for KBoRE for IST innovations, that it could be used by researchers from LATAM as a guide for future investigations.

After obtaining the dataset from the queries, we performed a filtering process, where articles with at least one characteristics of the list below were excluded from the dataset. Implementing this selection, we obtained a total of 525 articles with full information.

1. Absence of title, abstract or keywords (49 records).
2. Duplicate (6).
3. Journal or proceedings conference editorials, letters to the editor or non-peer review documents (7).

The sample of 525 articles included researchers related to RE and Innovation, but not necessarily about transformation in IST projects. For example, in Cleland-Huang, Rahimi, & Mirakhorli (2015), although RE and Innovation are topics discussed, authors did not study innovation in IST projects. Hence, we performed a heuristic analysis for excluding articles whose main purpose and subject are not related to IST innovation projects. Applying the heuristic exclusion process resulted on a final dataset of 212 articles.

Finally, once obtained the final dataset the articles were mapped onto the ontology, using the titles, abstracts and keywords. As it was discussed previously, this mapping process allowed us also to test the internal validity of the taxonomies and the face validity of the ontology, and to identify the bright and blind spots of KBoRE for IST innovations the sample. The mapping was performed by two coders independently, and in order to ensure the use of a same criteria, they first mapped a sample of 20 articles each one, and analyzed the convergence and differences of their coded data. In a first iteration, a convergence index of 60% was obtained (similarities of the mapping in the ontology). Then coders analyzed the divergences and similarities in the criteria, and discussed about the differences to reach convergence and establish rules for the coding of the rest of the articles in the sample, and to minor modifications to the ontology. Later, they mapped other 20 articles and analyzed the convergence of the second stage. In this iteration, the convergence ratio reached 90% of agreement in the coding process. Next, the rest of the articles was assigned to the coders and they mapped the articles onto the ontology. The results of the mapping are presented in the following section.

Mapping Results

According to the mapping, the most covered elements in the sample are the 'elicitation' and 'analysis' stages and 'method' under the Requirements Management subontology. In the Transformation Process subontology, the most documented concepts in the sample are 'describe' in the Activity taxonomy, and 'modification', 'disruption', and 'continuation' in the Innovation Degree. Frequency results are illustrated in Figure 2. Combining the most frequent elements in the ontology, the bright spots in the sample are listed as themes in which the current literature presents models, theories, frameworks, cases or empirical analyses:

** Requirement elicitation method to describe the continuation of IST/IST Projects*
** Requirement elicitation method to describe the modification of IST/IST Projects*
** Requirement elicitation method to describe the disruption of IST/IST Projects*
** Requirement analysis method to describe the continuation of IST/IST Projects*
** Requirement analysis method to describe the modification of IST/IST Projects*
** Requirement analysis method to describe the disruption of IST/IST Projects*

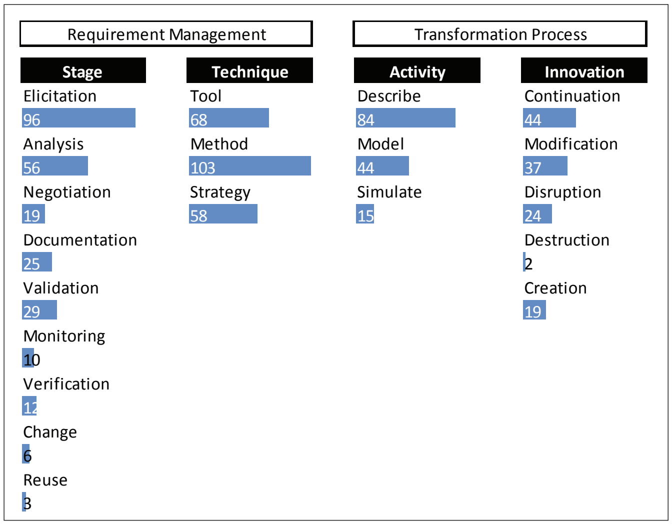
On the other hand, connecting the less mapped elements from the ontology, the blind spots would be:

** Requirement reuse to simulate the destruction of IST/IST Projects*
** Requirement reuse to simulate the creation of IST/IST Projects*
** Requirement change to simulate the destruction of IST/IST Projects*
** Requirement change to simulate the creation of IST/IST Projects*

In the four examples of blind spots in the literature, perhaps the less applicable to real life projects are those related to the reuse of requirements for the simulation of destruction (deactivation) of IST projects. However, the simulation of requirement changes and the reuse of requirements for the creation of IST are key unsolved topics in the RE literature and practice, but much needed in the industry of software development and IST project management. The small appearance or the absence of literature about the concepts of change and re-use of requirements, even when these are the most reported issues by IST developers as a source of conflicts with the end users and clients, perpetuates gaps between theory and practice that cost precious resources to IST projects, and in some cases pave the road to failures. Also, there seems to be a fertile field in studying IST simulations of the activity related to digital innovations, as well as negotiation, monitoring and verification of requirements, hence, researchers and practitioners could focus their efforts in identifying if these areas are interesting and relevant for research and then, study new techniques to reduce the knowledge gaps in the discipline, considering the industry's needs for prioritize the innovation in RE. In this vein, some surveys or case-studies could be conducted to identify the industry's needs in this domain. For example, in Chile there is a survey whose objective is identified several technological aspects of companies. This survey is named ENTI (National Study of Information Technology) and allows to collect data by interviewing 152 CIOs. One aspect measured is the Innovation and IT Management, and interesting results are obtained by the analysts, such as that one fifth of the interviewed considered her/his company as an Early Adopter profile and another similar size of group declares their companies invest when IT obsolescence risks are clearly close to capitalize. Plainly the IT Innovation would not be considered as a mature aspect in the Chilean industry, which may not change in the short time due they have not formal process for innovation. The ENTI analysts do not indicate if this companies require for more innovation, however, considering the global trends, these companies will eventually need implement a formal process.

The literature archives researches that indicates learnings and considerations in order to create proper ecosystems for the digitalization transformation process. For example, Villeal et al (2018), provide an extensive analysis of RE in the era of Digital Transformation by framing the review in a set of six domains to get the Ubiquitous RE (RE everywhere, RE with everyone, RE for everything, Automated RE, Open RE, Cross-domain RE). Their analysis identified the importance of taking down barriers and accepting the openness of the software ecosystem that engineers may confront. Also, they indicated the relevance of inventing in requirements and making assumptions for dealing with openness and provide five important lessons: (1) reduce the cycle to test assumptions and requirements, (2) implement an end-to-end thinking of ecosystem business, (3) consider at the same time the business, technical, and legal perspective, (4) align the business model operators and partners platform, and (5) ship platform versions fast in order to learn from stakeholders. Scilicet, researcher and practitioner may identify the bright/blink side in the literature and develop solutions based on RE approach for facilitate the IST innovations in the Digital Transformation required by organizations.

Figure 2. Frequency of the mapped proceedings onto the KBoRE for IST innovations Ontology.



Other type of analysis is related to dyads, where we identified pairs of elements mapped together in the articles. We provide in Figure 3 a matrix and the frequency of articles that include the two topics according the mapping done by the coders. The results illustrated that *elicitation-method* (44), the *method* to *describe* (38), *elicitation* to *describe* (33), *elicitation tool* (32), *analysis method* (26), *tool* to *describe* (25), *method* to *model* (25), and *describe* the *continuation* (24) are the most common pairs of elements studied in the sample. In second order, the pairs *elicitation-analysis, method-strategy*, *tool-method, method-continuation, method-modification, elicitation-continuation,* and *analysis-model* received so far moderated attention. Also, it is interesting to further analyze the pairs of concepts with a very low frequency or virtual absence of articles associated to them presented here as blind areas and a first point of interest to consider the development of solutions based for example, on artificial intelligence, business process management and machine learning tools.

Figure 3. Paired appearance of elements in the KBoRE for IST innovations Ontology.

		Stage									Technique			Activity			Innovation				
		Elicitation	Analysis	Negotiation	Documentation	Validation	Monitoring	Verification	Change	Reuse	Tool	Method	Strategy	Describe	Model	Simulate	Continuation	Modification	Disruption	Destruction	Creation
Stage	Elicitation																				
	Analysis	22																			
	Negotiation	6	6																		
	Documentation	14	5	2																	
	Validation	11	7	2	5																
	Monitoring	3	2	1	1	2															
	Verification	6	2	2	2	4	2														
	Change	2	0	0	0	0	1	1													
	Reuse	0	0	0	0	0	0	0	0												
Technique	Tool	32	17	8	10	11	3	3	0	0											
	Method	44	26	9	10	15	5	8	1	2	17										
	Strategy	21	17	2	6	7	1	3	2	0	7	19									
Activity	Describe	33	12	5	9	8	5	3	2	1	25	38	21								
	Model	14	19	3	2	9	1	4	0	0	8	25	12	3							
	Simulate	6	6	2	1	3	1	2	0	0	6	6	5	1	1						
Innovation	Continuation	19	10	1	7	3	2	4	3	0	14	17	18	24	10	2					
	Modification	14	11	2	2	5	2	2	1	0	10	17	9	19	7	1	10				
	Disruption	5	7	1	0	5	1	0	0	0	4	11	8	10	6	2	0	4			
	Destruction	1	0	0	0	1	0	1	0	0	0	1	1	1	0	1	0	1	1		
	Creation	8	7	0	0	2	0	0	0	0	5	8	7	4	9	1	1	0	5	0	

Discussion and Conclusion

The proposed ontology decomposed and then structured the body of knowledge of the RE in relationship with innovation in IST projects, providing a holistic view of the topics and areas included in the discipline of IST innovation. Furthermore, through mapping a sample of articles onto the ontology, it was possible to validate the construction and identify the bright and blind/blink areas of knowledge of the RE and Innovation corpus of the sample. According to the results, the publications documented in the sample obtained from two indexed, SCOPUS and WoS, databases have widely studied the methods of elicitation and analysis of requirements to describe modification, continuation and disruption processes in IST projects. Also, the findings reveal areas with lesser research evidenced in the sample such as change and reuse requirements, and simulation and creative destruction transformations. More topics related to the RE management such as negotiation, monitoring, verification and documentation of requirements during IST innovation processes, although not absent, are relatively understudied and could indicate the need and opportunities to theorize and discover solutions for practical and everyday problems in IST projects not covered yet.

According with the results, this ontology could be used as an input in order to design a research agenda to strategically fill the gaps in literature and systematically expand the scope and depth of the knowledge available in KBoRE for IST innovation. Moreover, for future research, although we lightly contrasted the identified gaps in the literature with some Latin American industry's needs, such the Chilean one, a deeper research on the whole zone is desired in order to prioritize what blind areas of the KBoRE must be according to a, for example, roadmap. Also, mapping a wider sample could robust the conclusions and identify new approaches for those RE techniques with the potential to impact IST innovations and reduce their failure rates and currently high risk. Finally, authors claim for the need of studies about RE in IST innovations in LATAM contexts, since, according to the results from queries, less than 4% of articles were related to Latin America countries.

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La Heterogeneidad de los Servicios Intensivos en Conocimiento: El Caso de Argentina**

Andrés López[1], Andrés Niembro[2]*

Resumen: El presente artículo busca contribuir al debate acerca de la heterogeneidad entre los servicios intensivos en conocimiento (SIC), sobre la base de una fuente de información novedosa que nos permite no sólo estudiar las características de los SIC a un mayor nivel de desagregación que el utilizado comúnmente en la literatura internacional, sino también analizar estas actividades en el marco de un país en desarrollo como la Argentina. Mediante una combinación de técnicas de análisis multivariado obtenemos una tipología empírica que nos brinda una visión más clara sobre los puntos en común y las diferencias entre los distintos tipos de SIC identificados. Esta contribución no sólo es útil para el mejor análisis de estos sectores, que han ganado fuerte peso en la economía global, sino también para los tomadores de decisión, ya que son muchos los países que están implementando políticas de desarrollo productivo dirigidas a los SIC.

Palabras clave: servicios intensivos en conocimiento; heterogeneidad; tipología; países en desarrollo; análisis multivariado

The heterogeneity of knowledge-intensive services: the case of Argentina

Abstract: The present paper seeks to contribute to the debate about the heterogeneity between knowledge-intensive services (KIS), based on a novel source of information that allows us not only to study the characteristics of KIS with a higher level of disaggregation than most of the international literature, but also to analyze these activities from the point of view of a developing country such as Argentina. Through a combination of multivariate analysis techniques we finally obtain an empirical typology that gives us a clearer picture about the similarities and differences among different types of KIS. Conclusions are relevant not only for the academic analysis of these sectors, which are increasingly relevant in the world economy, but also for policy makers, since many countries are implementing industrial policies aimed at promoting KIS.

Keywords: knowledge-intensive services; heterogeneity; typology; developing countries; multivariate analysis

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1. Introducción

A partir de la clasificación *residual* (o complementaria) adoptada varias décadas atrás por Fisher (1939) y Clark (1940), dentro del sector terciario o de servicios se incluyeron todos aquellos rubros que no podían ubicarse entre las actividades primarias o en las secundarias-manufactureras. Así, bajo el paraguas de los *servicios* se han englobado una gran variedad de actividades heterogéneas entre sí (Bastos y Perobelli, 2012; Glückler y Hammer, 2011; 2013). En años más recientes, como señalan Becker, Böttcher y Klingner (2011), debido a la toma de conciencia de esta heterogeneidad y también como una forma de manejarla, se han desarrollado diferentes esfuerzos por desagregar y/o re-clasificar a los servicios.

Por un lado, es posible encontrar distintas clasificaciones oficiales de actividades económicas, diseñadas y aplicadas por organismos estadísticos para estructurar la recopilación de información y facilitar el análisis de la misma. Por otra parte, como comenta Viitamo (2007), también se han derivado tipologías, tanto teóricas como empíricas, con el fin de resaltar ciertas características o dimensiones que en ocasiones pueden verse obscurecidas por las clasificaciones oficiales y que serían comunes a distintos subconjuntos o *clusters* de actividades de servicios.

No obstante, las tipologías teóricas resultan en cierta medida incompletas o parciales, ya que se basan en definiciones idiosincráticas y sus resultados dependen considerablemente de los criterios adoptados (Glückler y Hammer, 2011; 2013; Lee, Shim, Jeong y Hwang, 2003). En tanto, un problema asociado a muchas de las tipologías empíricas es que el análisis se suele realizar a partir de datos sectoriales a uno o dos dígitos de desagregación, impidiendo identificar las heterogeneidades hacia el interior de estos agregados.

Dentro de los servicios, un subconjunto particular que ha ganado crecientemente atención e importancia en las últimas décadas, pero que no se encuentra por ello al margen de las consideraciones generales anteriores, es el de los *servicios intensivos en conocimiento* (SIC). Este grupo de actividades, cuyo análisis remonta al aporte seminal de Miles et al. (1995), atrajo rápidamente el interés de investigadores y

** Versiones previas de este trabajo fueron presentadas durante 2017 en la VI Conferencia Internacional de REDLAS (San José, Costa Rica) y en la LII Reunión Anual de la Asociación Argentina de Economía Política (Bariloche, Argentina). Los autores agradecen los valiosos comentarios recibidos en ambos eventos como así también la gestión de la Secretaria de Transformación Productiva del Ministerio de Producción de la República Argentina para la obtención de los datos en los que se basa el presente artículo. Como es usual, los errores remanentes son de nuestra exclusiva responsabilidad.

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hacedores de política, ya que se trata de servicios de un elevado valor agregado, que generan puestos de trabajo de relativamente alta calificación y son una pieza fundamental en la *economía del conocimiento*, tanto por su propia inclinación hacia la innovación como por su rol en materia de transmisión de conocimiento y facilitación de las actividades innovativas en otros sectores (Den Hertog, 2000; Freel, 2006; Glückler y Hammer, 2011; Howells, 2000; Muller y Zenker, 2001; Schnabl y Zenker, 2013; Tether y Hipp, 2002).

En América Latina estos sectores también han tenido un desarrollo importante en los últimos años, aumentando incluso su inserción en los mercados externos, tal como se analizó en López, Niembro y Ramos (2014). En el caso de Argentina, según cálculos recientes de López (2018), los SIC han incrementado su participación tanto en materia de empleo como de valor agregado (lo cual está en línea con lo observado en los Estados Unidos y la Unión Europea), a la vez que ha crecido su vocación exportadora. Asimismo, cabe destacar que las empresas argentinas de SIC resultan más grandes que el promedio de la economía si se las mide por número de empleados y suelen pagar salarios también por encima de la media general. Esto se suma al hecho de que, en comparación con otros sectores, los sueldos y contribuciones sociales representan una parte considerable de los costos, todo lo cual refleja el carácter trabajo-intensivo de estas actividades (López, 2018). Sin embargo, como veremos luego, estas características generales pueden ocultar importantes diferencias entre los subsectores de SIC.

En algunos trabajos previos parece adoptarse la postura de que los servicios intensivos en conocimiento serían un conjunto de actividades relativamente homogéneas entre sí (Den Hertog y Bilderbeek, 2000; Tether, 2005). De hecho, varios estudios empíricos de países desarrollados y también de América Latina tienden a concentrarse únicamente en enfatizar las diferencias entre los SIC y el resto de las actividades de servicios (Aboal y Garda, 2016; Álvarez, Bravo-Ortega y Zahler, 2015; Asikainen, 2015; Crespi, Tacsir y Vargas, 2014; Dutrénit, De Fuentes, Santiago, Torres y Gras, 2013; Gallego, Gutiérrez y Taborda, 2015; Hollenstein, 2003; Tello, 2017; Tether, 2005; Torrecillas y Brandão Fischer, 2011). No obstante, hay quienes sostienen que en realidad existe una marcada heterogeneidad hacia el interior de los SIC (Consoli y Elche-Hortelano, 2010; Corrocher, Cusmano y Morrison, 2009; Doloreux, Amara y Landry, 2008). Por otra parte, varios de los trabajos sobre SIC se han basado en categorías (teóricas) muy agregadas, como por ejemplo la distinción de Miles et al. (1995) entre SIC tecnológicos y profesionales (Consoli y Elche-Hortelano, 2010; Corrocher et al., 2009; Freel, 2006; Muller y Zenker, 2001; Zenker y Doloreux, 2008), por lo que resulta necesario *bajar* un poco más para examinar las diferencias entre los sectores agrupados dentro de estos agregados. Sin embargo, la limitada disponibilidad de datos más allá de los dos dígitos en las distintas clasificaciones de actividades económicas ha restringido considerablemente la profundidad de estos esfuerzos (Doloreux et al., 2008; Schnabl y Zenker, 2013).

En este artículo, en cambio, la base de datos que disponemos nos permite trabajar a tres dígitos y así poder ser más precisos en la identificación de similitudes y diferencias entre las actividades que se incluyen dentro del universo de los SIC. Asimismo, en contraposición a otros trabajos que se basan en la validación empírica de tipologías conceptuales derivadas previamente (David, 2014; Freel, 2006; Hipp y Grupp, 2005; Verma y Boyer, 2000), buscamos analizar la heterogeneidad de los SIC a partir de los propios datos a nivel de sectores y extraer de este modo una tipología empírica. En este sentido, compartimos el punto de vista de Corrocher et al. (2009) de que es necesario explorar la *caja negra* de los SIC y que, para ello, hay que buscar patrones en los datos, dejando de lado los agregados sectoriales definidos por clasificaciones *a priori*, que pueden ocultar características posiblemente relevantes para diferenciar los sectores entre sí.

Dicho todo lo anterior, este artículo pretende contribuir al debate sobre la heterogeneidad hacia el interior de los SIC sobre la base de una fuente de información novedosa que permite, por un lado, estudiar las características de estas actividades económicas a tres dígitos de desagregación y, por otro, analizar el caso de un país en desarrollo de América Latina como la Argentina. Mediante una combinación de técnicas de análisis multivariado, se obtiene finalmente una tipología empírica que brinda una visión más clara y concreta sobre los puntos en común y las diferencias entre los distintos tipos de SIC.

El artículo se estructura de la siguiente forma. En la segunda sección se realiza una breve reseña de la literatura que antecede al presente trabajo. Luego, en la tercera sección se describen las fuentes de información y los datos utilizados, como así también las técnicas multivariantes y los criterios metodológicos adoptados. La cuarta sección reúne los resultados obtenidos en las distintas etapas del estudio: por un lado, los componentes principales y las dimensiones de análisis; y por otro, los clusters y distintos tipos de SIC identificados. Por último, se concluye con algunas reflexiones finales a partir de dicho ejercicio.

2. Marco conceptual y antecedentes

A lo largo del tiempo se ha ido gestando una importante cantidad de esfuerzos de desagregación, clasificación o desarrollo de tipologías para el sector de servicios (Becker et al., 2011; Browning y Singelmann, 1975; Cook, Goh y Chung, 1999; Liu, Wang y Lee, 2008; Lovelock, 1983; Meiren et al., 2015; Shafti, Van Der Meer y Williams, 2007; Silvestro, Fitzgerald, Johnston y Voss, 1992; Stigler, 1956). Por dar algunos ejemplos, Becker et al. (2011) identifican entre 1923 y 2011 un total de 81 sistemas de clasificación de servicios, mientras que Meiren et al. (2015) encuentran que se han utilizado más de 50 criterios diferentes para tal propósito.

Dentro de esta gran diversidad, y teniendo en cuenta el objetivo del presente artículo, vale destacar algunos trabajos que han recurrido a técnicas de análisis multivariante para contrastar empíricamente tipologías conceptuales o bien para derivar tipologías empíricas a partir de los datos y sin adoptar una taxonomía teórica *a priori*. En el primero de los casos se ubica el aporte de Verma y Boyer (2000), quienes emplean el análisis factorial para *testear* y validar empíricamente una tipología desarrollada previamente por Schmenner (1986). Por su parte, David (2014) recurre a datos económicos y al análisis de componentes principales para recrear, triangular y validar la clasificación de servicios realizada previamente por Shafti et al. (2007).

Dentro del segundo grupo se encuentra el trabajo de Meiren et al. (2015), quienes derivan empíricamente una tipología de servicios a partir de una base de datos de empresas de diferentes sectores y países, utilizando tanto el análisis factorial, para reducir el número de dimensiones de comparación, como así también el análisis cluster, para armar grupos de empresas con características similares entre sí y, a su vez, diferentes de las cualidades de otros conjuntos.

Con respecto a los sectores de nuestro interés, y siguiendo la definición seminal de Miles et al. (1995), los servicios intensivos en conocimiento abarcan a todas aquellas actividades de servicios que impactan en la creación, acumulación o difusión de conocimiento. De modo similar, Den Hertog (2000) señala que los SIC funcionan tanto como fuente de innovaciones así también como facilitadores o transmisores de las mismas y que se requiere de un fuerte componente de conocimiento profesional o experiencia en disciplinas técnicas específicas para poder proveer este tipo de servicios. Rubalcaba, Gallego y Den Hertog (2010) también destacan que, a diferencia de los servicios más tradicionales, los SIC se caracterizan por el papel central que juega el conocimiento acumulado en el personal y las rutinas organizacionales. Es por esto que tanto los *inputs* como los *outputs* de los SIC incluyen un alto grado de conocimiento tácito (Doloreux et al., 2008). En palabras de Hipp y Grupp (2005), los SIC tienden a combinar conocimientos de diferentes fuentes y luego distribuir nuevo conocimiento hacia el resto de la economía, mientras que Schnabl y Zenker (2013) sostienen que las firmas de estos sectores se suelen ocupar de la recolección, procesamiento y tratamiento del conocimiento y de su adaptación a las necesidades de los clientes. En definitiva, los SIC comparten la característica de emplear capital humano de relativamente alto nivel de calificación y de ser usuarios y, en general también, productores de información y conocimiento.

Respecto al estudio de los SIC, en primera instancia surgieron una serie de tipologías teóricas derivadas de modelos conceptuales o bien de matrices donde se entrecruzaban distintas características de dichas actividades. Un ejemplo es la taxonomía de innovación en servicios presentada por Miozzo y Soete (2001), la cual se inspiraba y aportaba una extensión a la contribución original de Pavitt (1984). Por otra parte, en el trabajo seminal de Miles et al. (1995: 29-30) se diferencian los "nuevos servicios intensivos en tecnología" (T-SIC), mayormente relacionados con la oferta vinculada a las TICs y ciertas actividades técnicas, de los "servicios profesionales tradicionales" (P-SIC), eventualmente usuarios de las nuevas tecnologías (que, entre otras cosas, *habilitan* el surgimiento también de nuevas líneas de negocios).

Sobre esta base, varios trabajos apuntaron a contrastar empíricamente dichas tipologías teóricas. Por ejemplo, Hipp y Grupp (2005) *testean* la taxonomía de Miozzo y Soete con datos provenientes de Alemania, mientras que otros hacen lo propio a partir de la distinción entre T-SIC y P-SIC (Consoli y Elche-Hortelano, 2010; Corrocher et al., 2009; Doloreux et al., 2008; Freel, 2006; Muller y Zenker, 2001; Zenker y Doloreux, 2008). En general, se suele corroborar la existencia de diferentes patrones de comportamiento y evolución entre estos grupos de servicios, pero sin ahondar hacia el interior de los distintos sectores que los componen.

Otros autores han optado por desarrollar sus propias tipologías teóricas y luego validarlas empíricamente. Este es el caso, por ejemplo, de Von Nordenflycht (2010), quien sugiere la existencia de cuatro tipos diferentes de empresas de servicios (profesionales) intensivos en conocimiento e intenta ilustrar la utilidad de dicha tipología a partir de datos de los Estados Unidos. Por su parte, Glückler y Hammer (2011; 2013) cruzan de forma conceptual tres dimensiones de análisis (orientación de la demanda, intensidad de conocimiento e intensidad tecnológica) e identifican cinco tipos diferentes de servicios, aunque sólo tres de estos corresponden a variantes de SIC (para el consumidor, empresariales y tecnológicos). En base a datos de Alemania a tres dígitos (según la clasificación europea NACE), clasifican 93 sectores entre estas cinco categorías y verifican la capacidad de dicha tipología para dar cuenta de la heterogeneidad sectorial y regional en el desarrollo de estas ramas de actividad.

En un aporte que guarda cierto vínculo con el presente artículo, Chica Mejía (2011) parte de la clasificación de sectores intensivos en conocimiento de la OCDE (que incluye tanto manufacturas como servicios) y realiza un análisis de componentes principales seguido por un análisis cluster para identificar conjuntos de sectores relativamente homogéneos en materia de calificación y formación de sus recursos humanos. De esta forma, verifica que existe una relación entre los grupos que reúnen a las ocupaciones más calificadas y los sectores que la OCDE clasifica como intensivos en conocimiento y tecnología.

Por otro lado, una orientación particular de la literatura de servicios ha sido el estudio (llevado a cabo mayormente de forma descriptiva) de los diferentes tipos de patrones de innovación que pueden encontrarse entre las actividades de servicios en general o específicamente de los SIC, enfatizándose la existencia de una marcada heterogeneidad inter-sectorial o entre grupos de sectores (Consoli y Elche-Hortelano, 2010; Doloreux et al., 2008; Freel, 2006; Lee et al., 2003; Tether, 2003; Tether y Hipp, 2002; Tödtling, Lehner y Trippl, 2006; Wong y He, 2005). A su vez, algunos trabajos en esta línea han recurrido al uso de técnicas de análisis multivariado, combinando usualmente el análisis factorial y el análisis cluster para comparar e identificar diferencias entre sectores y, eventualmente, proponer una tipología empírica sobre esta base (Asikainen, 2015; Corrocher et al., 2009; Evangelista, 2000).

Otra rama cercana de la literatura empírica se ha ocupado de clasificar las estrategias o patrones de innovación de las empresas de servicios (no de los sectores) y, a su vez, varios de estos aportes han apelado metodológicamente a la técnica de análisis cluster para el desarrollo de dichas tipologías (De Jong y Marsili, 2006; Elche Hortelano y Gongález-Moreno, 2007; Hollenstein, 2003; Jordá Borrell, 2007). En general, de estos trabajos sobresalen tanto la heterogeneidad hacia el interior de las firmas de servicios como también cierta diferenciación con las categorías previamente desarrolladas para sectores manufactureros.

Por último, vale destacar que la mayor parte de los trabajos empíricos mencionados se basan en evidencia recolectada en países desarrollados, con la excepción de la inclusión de México en Meiren et al. (2015). En el caso específico de América Latina, una serie de aportes relativamente recientes han buscado analizar los patrones de innovación en servicios en algunos países de la región, pero distinguiendo únicamente entre el conjunto de los SIC y el resto de los servicios tradicionales (Aboal y Garda, 2016; Álvarez et al., 2015; Crespi et al., 2014; Dutrénit et al., 2013; Gallego et al., 2015; Tello, 2017). A su vez, en la mayoría de estos trabajos la categoría de SIC se establece agregando sectores a 2 dígitos o incluso a 1 dígito, como en los casos de Chile y Perú (Álvarez et al., 2015; Tello, 2017). Por otro lado, y en línea con la metodología adoptada en este artículo (que desarrollaremos a continuación), Bastos y Perobelli (2012) recurren al análisis factorial para clasificar todos los sectores de servicios en Brasil (comprobando la heterogeneidad entre los mismos) y Borrastero (2014) utiliza el análisis factorial y cluster para agrupar a las empresas innovadoras en el sector de software de Argentina según el acceso a las políticas públicas nacionales.

3. Datos y metodología

Aunque en la literatura se han propuesto definiciones distintas sobre el concepto de *servicios intensivos en conocimiento* (Den Hertog, 2000; García-Quevedo, Mas-Verdú y Montolio, 2013; Wood, 2002), en la práctica hay cierto consenso sobre cuáles son los sectores que pertenecen al universo de los SIC, basado en gran medida en una serie de ejercicios de identificación y clasificación realizados en Europa y que ya se han establecido como una norma estándar a nivel internacional (Doloreux et al., 2008; García Manjón, 2008; Muller y Doloreux, 2009; Schnabl y Zenker, 2013; Torrecillas y Brandão Fischer, 2011). De igual manera, en este trabajo se toma como punto de partida el conjunto de sectores de SIC propuesto por Eurostat (cuadro 1), el cual apunta a dar una cobertura relativamente amplia de este tipo de servicios.

No obstante, algunos de los sectores que Eurostat considera dentro de los SIC no podrán ser analizados en este trabajo (y se encuentran marcados en gris en el cuadro 1). Esto se debe a que nuestra principal fuente de información consiste en datos tributarios suministrados por la Administración Federal de Ingresos Públicos (AFIP), correspondientes a las presentaciones realizadas por las empresas del Impuesto al Valor Agregado (IVA), Seguridad Social y Ganancias de las sociedades. Si bien se trata de una fuente novedosa de datos para este tipo de ejercicios, y al igual que Stigler (1956) consideramos que los impuestos recaudados a nivel nacional representan una de las bases de información más detalladas, existen algunas limitaciones. La principal es que hay sectores, como los de la administración pública, educación, salud y servicios sociales, que no se encuentran suficientemente cubiertos con este tipo de impuestos, ya que gran parte de su provisión corresponde a organismos públicos o bien, por su fin social, las entidades privadas pueden acceder a distintos tipos de exenciones.

Cuadro 1. Actividades incluidas en la definición de SIC de Eurostat (NACE Rev.2 a 2 dígitos). Traducción propia de la clasificación de Eurostat.[1]

Servicios *high-tech* intensivos en conocimiento (H-T)	
59	Producción de películas, video y televisión, grabación de sonido y publicación de música
60	Actividades de programación y difusión
60	Telecomunicaciones
62	Programación de computadoras, consultoría y actividades relacionadas
63	Actividades de servicios de información
72	Investigación y desarrollo científico
Servicios empresariales intensivos en conocimiento (E)	
50	Transporte acuático
51	Transporte aéreo
69	Actividades legales y contables
70	Actividades de oficinas centrales y consultoría de gestión
71	Actividades de arquitectura e ingeniería, pruebas y análisis técnicos
73	Publicidad e investigación de mercados
74	Otras actividades profesionales, científicas y técnicas
78	Actividades de empleo (recursos humanos)
80	Actividades de seguridad e investigación
Servicios financieros intensivos en conocimiento (F)	
64	Actividades de servicios financieros, excepto seguros y fondos de pensiones
65	Seguros, reaseguros y fondos de pensiones, excepto la seguridad social obligatoria
66	Actividades auxiliares a servicios financieros y de seguros
Otros servicios intensivos en conocimiento (O)	
58	Actividades de edición
75	Actividades veterinarias
84	Administración pública y defensa; seguridad social obligatoria
85	Educación
86	Actividades de salud humana
87	Actividades de cuidado residencial
88	Actividades de trabajo social sin alojamiento
90	Actividades creativas, artísticas y de entretenimiento
91	Bibliotecas, archivos, museos y otras actividades culturales
92	Actividades de juegos de azar y apuestas
93	Actividades deportivas, de entretenimiento y recreación

[1] Ver: http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Knowledge-intensive_services_(KIS)

Por otro lado, en este trabajo optamos por incorporar algunos subsectores que Eurostat no considera dentro de su clasificación de SIC, pero que pueden ser de relevancia para el contexto de países en desarrollo como la Argentina. Como señalan Muller y Doloreux (2009), aunque algunos servicios especializados ligados a la explotación de recursos naturales no suelen incluirse entre los servicios intensivos en conocimiento, se puede tratar de actividades con características similares a estos, por ejemplo, en cuanto a los niveles de calificación del personal y el uso de nuevas tecnologías. De este modo, incluimos dentro de nuestra clasificación de SIC algunos servicios de apoyo a la actividad primaria, como así también a la gestión y logística y otros servicios empresariales no tenidos en cuenta en el caso europeo, pero que sí son de interés para países como los latinoamericanos (ver cuadro 2, donde estos sectores se resaltan en gris).

Una última diferencia con la clasificación de Eurostat, que responde al señalado interés por utilizar categorías menos agregadas, es que trabajamos con datos a 3 dígitos en lugar de 2. Para ello, hemos tenido que recortar nuestro horizonte de análisis a la información tributaria de 2014, ya que sólo para este último año los datos de AFIP disponibles se presentan a un mayor nivel de desagregación.

Otra particularidad de nuestra fuente de información es que los datos suministrados se encuentran agregados a nivel sectorial. El hecho de trabajar con promedios sectoriales impide analizar la heterogeneidad interna a cada actividad, ya que no disponemos de información acerca de la distribución de las firmas en torno a dichos promedios. Quedará para futuros trabajos avanzar en esa dirección en la medida en que se pueda acceder a información a nivel de empresa.

Más allá de los tradicionales límites que imponen la existencia de una economía informal y/o la subdeclaración de ingresos sobre la fiabilidad de los datos impositivos, también hay algunos otros puntos a tener presentes. Por ejemplo, cuando la información proviene de declaraciones juradas en donde las empresas informan su desempeño en las distintas variables de interés para su principal rama de actividad, puede *perderse* la información de aquellas firmas que también proveen SIC pese a que estos no son su negocio central (por ejemplo, una empresa industrial multinacional que tiene un centro de servicios compartidos que abastece a otras filiales de la corporación). Por otro lado, en muchos sectores podrían convivir empresas que efectivamente prestan SIC con otras que proveen servicios menos sofisticados. Asimismo, esta fuente de datos no incluye, por su propia naturaleza, ciertas variables que serían valiosas para una tipología de SIC (teniendo en cuenta la literatura internacional), como por ejemplo las vinculadas a actividades innovativas.

Cuadro 2. Actividades incluidas en nuestra definición de SIC (CLAE-AFIP a 3 dígitos)[1]

Servicios *high-tech* intensivos en conocimiento (H-T)	
591	Servicios de cinematografía
592	Servicios de grabación de sonido y edición de música
601	Emisión y retransmisión de radio
602	Servicios de televisión
611	Servicios de telefonía fija
612	Servicios de telefonía móvil
613	Servicios de telecomunicaciones vía satélite, excepto servicios de transmisión de televisión
614	Servicios de telecomunicación vía internet
619	Servicios de telecomunicaciones n.c.p.
620	Servicios de programación y consultoría informática y actividades conexas
631	Procesamiento de datos, hospedaje y actividades conexas; portales web
639	Servicios de agencias de noticias y servicios de información
721	Investigación y desarrollo experimental en el campo de la ingeniería y de las ciencias exactas y naturales
Servicios empresariales intensivos en conocimiento (E)	
016-024	Servicios de apoyo a la agricultura, ganadería y silvicultura
091-099	Servicios de apoyo para la minería, petróleo y gas natural
421-422-429	Construcción de obras de ingeniería civil
501	Servicio de transporte marítimo
502	Servicio de transporte fluvial y lacustre
511	Servicio de transporte aéreo de pasajeros
512	Servicio de transporte aéreo de cargas
523	Servicios de gestión y logística para el transporte de mercaderías
691	Servicios jurídicos
692	Servicios de contabilidad, auditoría y asesoría fiscal
702	Servicios de asesoramiento, dirección y gestión empresarial
711	Servicios de arquitectura e ingeniería y servicios técnicos n.c.p.
712	Ensayos y análisis técnicos
731	Servicios de publicidad
732	Estudio de mercado, realización de encuestas de opinión pública
741	Servicios de diseño especializado
742	Servicios de fotografía
749	Actividades profesionales, científicas y técnicas n.c.p.
780	Obtención y dotación de personal
801	Servicios de seguridad e investigación
822	Servicios de call center
821-823-829	Otros servicios empresariales de apoyo
Servicios financieros intensivos en conocimiento (F)	
641	Intermediación monetaria
649	Servicios financieros, excepto los de la banca central y las entidades financieras
651	Servicios de seguros
661	Servicios auxiliares a la actividad financiera, excepto a los servicios de seguros
662	Servicios auxiliares a los servicios de seguros
663	Servicios de gestión de fondos a cambio de una retribución o por contrata
Otros servicios intensivos en conocimiento (O)	
581	Edición
750	Servicios veterinarios
900	Servicios artísticos y de espectáculos
920	Servicios relacionados con juegos de azar y apuestas
931	Servicios para la práctica deportiva
939	Servicios de esparcimiento n.c.p.

[2] La Clasificación de Actividades Económicas de la AFIP (CLAE-AFIP) se basa en la Clasificación Industrial Internacional Uniforme (CIIU) Rev. 4 y la Clasificación Nacional de Actividades Económicas (ClaNAE 2010) del Instituto Nacional de Estadísticas y Censos (INDEC). Aunque pueden haber algunas diferencias puntuales, a los fines del recorte de actividades de este trabajo las clasificaciones NACE y CLAE-AFIP resultan muy similares.

Sin perder de vista estas limitaciones, consideramos de todas formas que los datos disponibles representan una fuente de información valiosa en un área donde las estadísticas no abundan. Las distintas variables que se utilizan en el análisis multivariado (cuadro 3) abarcan diferentes indicadores tradicionales del desempeño empresarial, que describen aspectos económicos, productivos y/o financieros de las firmas de cada sector.

Cuadro 3. Variables empleadas en el análisis

Variable	Descripción	Unidad de medición	Origen de la información
Ventas	Volumen de ventas promedio: ventas totales, dividido por el número de presentaciones	Pesos corrientes	IVA
Empleo	Empleo promedio: cantidad de empleados, dividido por el número de empleadores del sector	Cantidad de empleados	Seguridad social
Remuneraciones	Remuneración promedio para el sector	Pesos corrientes	Seguridad social
VA_Empleado	Valor agregado, dividido por el número de empleados	Pesos corrientes	Seguridad social y Ganancias
VA_Ventas	Valor agregado, dividido por las ventas totales (por 100)	Porcentaje	Ganancias
Compras_Costo	Compras netas, dividido por el costo total (por 100)	Porcentaje	Ganancias
SalariosProd_Costo	Salarios de personal de producción, dividido por el costo total (por 100)	Porcentaje	Ganancias
SalariosTot_Costo	Salarios totales (de personal de producción y operativos), dividido por el costo total (por 100)	Porcentaje	Ganancias
BienesUso_Ventas	Bienes de uso, dividido por las ventas totales (por 100)	Razón	Ganancias
BienesUso_Activo	Bienes de uso, dividido por los activos totales (por 100)	Porcentaje	Ganancias
ResultadoB_Activo	Resultado bruto (utilidades menos pérdidas), dividido por los activos totales (por 100)	Razón	Ganancias
VentasN_Activo	Ventas netas, dividido por los activos totales (por 100)	Razón	Ganancias

Estos datos serán empleados para realizar, primero, un análisis de componentes principales y, en segunda instancia, un análisis cluster a partir de los componentes previamente extraídos. Esto nos ha llevado a que algunos otros indicadores alternativos disponibles tuvieran que ser desechados, ya que no cumplían con los requisitos estadísticos para formar parte del análisis de componentes principales: análisis de la matriz de correlaciones, test de esfericidad de Bartlett, medida de adecuación muestral KMO, análisis de las comunalidades (para más detalles, ver Hair, Black, Babin y Anderson, 2010).

En términos generales, el propósito central del análisis factorial, y del método de componentes principales en particular, es poder definir y comprender la *estructura* subyacente a las variables analizadas; o en otras palabras, condensar la mayor parte de la información y variabilidad contenida en un conjunto de variables originales a partir de un menor número de dimensiones comunes, que en última instancia responden a combinaciones lineales de aquellas variables (Hair et al., 2010; Johnson y Wichern, 2008). Esto nos es de particular utilidad, puesto que permite reunir la información compartida por declaraciones impositivas diferentes y que, por ende, cubren a distintos universos de empresas en cada sector.

Por otra parte, el análisis factorial puede funcionar más como *un medio para un fin* que como *un fin en sí mismo* (Johnson y Wichern, 2008), ya que dado que los factores o componentes principales no se encuentran correlacionados entre sí podrían aprovecharse como insumos intermedios para otras técnicas como, por ejemplo, el análisis cluster. Por último, los supuestos y criterios necesarios para una correcta aplicación del análisis de factores pueden ser de utilidad al momento de seleccionar (las *mejores*) variables entre un conjunto más amplio de indicadores.

Un punto a tener en cuenta es que la técnica de componentes principales es sensible a cambios de escala o al uso de diferentes rangos de medidas, por lo que inicialmente es necesario estandarizar las variables, algo que por lo general la mayoría de los programas estadísticos suele realizar por medio de los *Z scores*. Es decir, a las variables originales se les resta la media y luego se dividen por el desvío estándar, de forma que una vez estandarizadas tengan media 0 y desvío 1.

Por su parte, la técnica de análisis cluster o de conglomerados comparte con el análisis factorial el propósito de evaluar la estructura subyacente a los datos. No obstante, mientras que el análisis de factores suele emplearse para agrupar variables en función de los patrones de correlación existentes, la conformación de clusters apunta a generar grupos de casos sobre la base de la *proximidad* entre los mismos (Hair et al., 2010). El objetivo ulterior del análisis cluster es maximizar la homogeneidad (en función de las características seleccionadas) entre los casos incluidos dentro de cada cluster, al mismo tiempo que se maximiza la heterogeneidad entre los clusters conformados. Esto permite distinguir las particularidades de cada grupo, asignarles un nombre o descripción a cada uno y, en función de ello, definir una tipología empírica.

Entre los métodos disponibles para definir la conformación de los clusters, en este trabajo recurrimos a la técnica no jerárquica de K-Medias (el método no jerárquico más común, por lo que en algunos programas estadísticos es el único que figura) y a la distancia Euclídea como medida de proximidad (la más usual para esta técnica, al punto que en ciertos programas viene así por defecto). A diferencia de la irreversibilidad de los métodos jerárquicos[2], dado que una vez que dos casos o clusters se unieron, quizás de manera *incorrecta*, no hay forma de que los mismos puedan re-localizarse *correctamente* en etapas posteriores (Hair et al., 2010; Johnson y Wichern, 2008), el procedimiento de K-Medias permite una mejor asignación de los casos entre los diferentes clusters. Mediante una serie de iteraciones se va redefiniendo la ubicación de cada caso hacia el cluster con media más similar, hasta el punto donde se alcanza la *mejor* solución posible y nuevas relocalizaciones carecen de sentido. Tal vez el mayor requisito para la aplicación de esta técnica es que debe definirse de antemano el número de clusters a conformar, para lo cual tomaremos como criterio (o *stopping rule*) a la regla de Calinski-Harabasz (CH). Lamentablemente, no se puede aplicar la *lower bound technique*, desarrollada especialmente para K-Medias por Steinley y Brusco (2011), ya que, como veremos luego, el número de clusters que se desea verificar excede a la cantidad de variables empleadas (los componentes principales). En casos como este, los mismos autores recomiendan el uso de CH.

4. Resultados

4.1. Principales componentes y dimensiones de análisis

El primer paso de la aplicación del análisis de componentes principales, a partir de las variables antes señaladas, consiste en definir el número de componentes a extraer. En este caso, el criterio de Kaiser (o del autovalor) sugiere seleccionar los primeros cinco componentes, los cuales en conjunto dan cuenta de más del 80% de la varianza total (cuadro 4).

Cuadro 4. Componentes, autovalores y varianza explicada

Componente	Autovalor	% Varianza	% Acumulado
1	3,278	25,22	25,22
2	2,584	19,87	45,09
3	2,177	16,74	61,83
4	1,724	13,26	75,10
5	1,141	8,78	**83,88**

En segundo lugar, en el cuadro 5 se presentan las cargas factoriales de las distintas variables en los cinco componentes extraídos (luego de aplicar la rotación VARIMAX), lo que ayuda a entender qué tipo de información estarían condensando cada una de estas dimensiones. El primero de los componentes, aquel que da cuenta de la mayor variabilidad (una cuarta parte de la varianza total), presenta un alto peso de los indicadores salariales, como así también cierta incidencia negativa de las compras en el costo total. Por esto, consideramos que este componente representaría al grado de *intensidad en recursos humanos*. En el caso del segundo componente, sobresalen tanto el resultado bruto como las ventas netas en relación con los activos de las firmas del sector, por lo que podemos sugerir que esta dimensión responde al grado de *eficiencia y/o rentabilidad empresarial*. En tercer lugar, se destacan el empleo y las ventas promedio, dos variables que reflejarían, cada una desde distintas ópticas, el *tamaño y volumen de negocios*. El cuarto componente, en tanto, reúne a los dos indicadores alternativos que caracterizan a la *intensidad en bienes de uso*. Por último, las variables con mayores cargas en el quinto componente son las que representan al valor agregado, las remuneraciones promedio y, nuevamente con signo negativo, la proporción del costo total asignado a compras. Lo interesante de esta dimensión es que el valor agregado en los sectores de servicios intensivos en conocimiento pareciera ir de la mano positivamente del nivel de remuneraciones del personal. En otras palabras, el vínculo entre *altas remuneraciones y valor agregado* (denominación que asignamos al último componente) daría cuenta nuevamente de la centralidad de los recursos humanos (calificados) en los SIC, pero también podría reflejar, como veremos más adelante, la existencia de ciertas condiciones que permiten en algunos sectores la emergencia de ingresos empresarios extraordinarios que pueden ser parcialmente absorbidos por la fuerza de trabajo respectiva.

[3] Los métodos jerárquicos consisten en una serie de pasos de combinación de casos según el grado de similitud (o distancia) entre los mismos, que gráficamente adoptan la forma de un diagrama de árbol o, más técnicamente, un *dendrograma*.

Cuadro 5. Pesos factoriales y comunalidades de las variables

	Comp.1	Comp.2	Comp.3	Comp.4	Comp.5	Comunalidad
Compras_Costo	-0,6172	0,0231	0,0541	0,0726	-0,6385	0,7974
SalariosProd_Costo	0,9521	0,1301	-0,0438	-0,0748	-0,1092	0,9428
SalariosTot_Costo	0,9459	-0,0164	0,0949	-0,1120	-0,1104	0,9288
ResultadoB_Activo	0,0376	0,9742	-0,1083	-0,0565	0,0188	0,9658
VentasN_Activo	0,0402	0,9743	-0,1084	-0,0565	0,0228	0,9664
Empleo	0,2936	-0,1746	0,8948	-0,0938	0,0287	0,9270
Ventas	-0,2113	-0,1095	0,9097	-0,0349	0,2064	0,9281
BienesUso_Ventas	-0,0782	-0,2341	-0,0482	0,9303	0,1117	0,9413
BienesUso_Activo	-0,1084	0,1046	-0,0755	0,9260	-0,0318	0,8868
VA_Empleados	-0,3083	0,2673	0,3506	-0,0496	0,6253	0,6828
VA_Ventas	-0,2283	0,0984	0,1888	0,3024	0,7574	0,7625
Remuneraciones	-0,1402	-0,4498	0,2144	-0,0725	0,6146	0,6509

4.2. Clusters y tipos de SIC

Sobre la base de los cinco componentes estimados para cada uno de los sectores de SIC, realizamos luego un análisis cluster no jerárquico. En el siguiente cuadro pueden apreciarse los valores arrojados por el test de CH si se conforman entre 2 y 9 clusters, donde se resaltan (en negrita) los números recomendados según esta regla. Usualmente, la aglutinación de casos muy diversos entre sí en una cantidad acotada de conglomerados puede no ser la opción más adecuada, por lo que un menor número de clusters suele ser descartado. En el otro extremo, mientras más clusters se formen, mejor se podrán reflejar las diferencias entre casos, incluso pudiendo conformarse uno o varios clusters de un único miembro (en el límite, podrían existir tantos clusters como casos). Sin embargo, no es esto lo que se busca precisamente con los ejercicios de *clusterización*, por lo que es recomendable además seguir algún criterio de *parsimonia* que apunte a adoptar la menor cantidad de clusters recomendada por la regla (Hair et al., 2010). En este sentido, optamos por un número de seis clusters para la aplicación del método de K-Medias.

Cuadro 6. S*topping rule* para K-Medias

	Número de clusters							
	2	3	4	5	**6**	7	**8**	**9**
Calinski/Harabasz pseudo-F	6,60	9,20	10,90	10,31	**11,31**	9,61	**14,42**	**13,34**

Otro tipo de validación consiste en verificar que los seis clusters que se conforman a partir de la técnica de K-Medias efectivamente exhiben características heterogéneas. Como puede apreciarse de forma satisfactoria en el cuadro 7, el análisis de la varianza (ANOVA) sostiene que la media de los distintos conglomerados para cada variable de estudio es significativamente diferente entre sí (la hipótesis nula del contraste es que la media de los grupos es igual).

Cuadro 7. Análisis de la varianza (ANOVA). Nivel de significación: * p<0,05; ** p<0,01; *** p<0,001.

Componente	Suma de cuadrados	Grados de libertad	Media cuadrática	F
1	5,737	5	0,422	13,583***
2	4,61	5	0,56	8,235***
3	7,436	5	0,215	34,558***
4	5,303	5	0,475	11,158***
5	4,808	5	0,536	8,977***

En cuanto al análisis de los clusters conformados (gráfico 1), un primer aspecto general a resaltar es que cada uno de estos cinco grupos reúne a sectores de servicios catalogados por Eurostat bajo distintas categorías (SIC *High-Tech*, Empresariales, Financieros y Otros). También es interesante que cuatro de los cinco clusters contengan a uno o más sectores considerados de *alta tecnología* junto con ramas de actividad provenientes de otros tipos de SIC. Esto refleja la necesidad de validar las categorías teóricas contra el uso de información empírica que refleja las características estructurales de los distintos sectores.

Otra cuestión destacable es que la utilización de datos desagregados a 3 dígitos permite apreciar que varios sectores de servicios, a pesar de provenir de antemano de una misma categoría estadística a 2 dígitos, aparecen aquí posicionados en diferentes clusters. En otras palabras, varios de estos sectores *hermanos* presentan características significativamente heterogéneas entre sí. Quizás el ejemplo más evidente sea el de los distintos subsectores de telecomunicaciones (rama 61), que aquí aparecen desperdigados en cuatro clusters, pero algo similar ocurre con los servicios jurídicos y contables, financieros y técnicos, entre otros.

Gráfico 1. Sectores de SIC por cluster

Cluster	Tipo de SIC	Sector de servicios (CLAE-AFIP)	
A	H-T	Servicios de cinematografía	
		Servicios de grabación de sonido y edición de música	
		Servicios de telecomunicación vía internet	(61)
		Servicios de programación y consultoría informática y actividades conexas	
	E	Servicios de apoyo a la agricultura, ganadería y silvicultura	
		Servicios de gestión y logística para el transporte de mercaderías	
		Servicios de arquitectura e ingeniería y servicios técnicos n.c.p.	(71)
		Construcción de obras de ingeniería civil	
		Servicios de publicidad	(73)
		Servicios de diseño especializado	
		Servicios de fotografía	
		Otros servicios empresariales de apoyo	
	F	Servicios auxiliares a la actividad financiera, excepto a los servicios de seguros	(66)
	O	Edición	
		Servicios veterinarios	
		Servicios artísticos y de espectáculos	
B	H-T	Emisión y retransmisión de radio	(60)
		Procesamiento de datos, hospedaje y actividades conexas; portales web	
		Servicios de agencias de noticias y servicios de información	
		Investigacion y desarrollo experimental en el campo de la ingeniería y de las cs. exactas y naturales	
	E	Servicios de apoyo para la minería, petroleo y gas natural	
		Servicios de contabilidad, auditoría y asesoría fiscal	(69)
		Servicios de asesoramiento, dirección y gestión empresarial	
		Ensayos y análisis técnicos	
		Actividades profesionales, científicas y técnicas n.c.p.	(71)
		Obtención y dotación de personal	
		Servicios de seguridad e investigación	
		Servicios de call center	
C	H-T	Servicios de televisión	(60)
		Servicios de telefonía fija	(61)
		Servicios de telecomunicaciones n.c.p.	(61)
	O	Servicios para la práctica deportiva	
		Servicios de esparcimiento n.c.p.	
D	E	Servicio de transporte marítimo	
		Servicio de transporte fluvial y lacustre	
		Servicio de transporte aéreo de pasajeros	
		Servicio de transporte aéreo de cargas	
	F	Servicios financieros, excepto los de la banca central y las entidades financieras	(64)
		Servicios de seguros	
		Servicios de gestión de fondos a cambio de una retribución o por contrata	
E	H-T	Servicios de telecomunicaciones vía satélite, excepto servicios de transmisión de televisión	(61)
	E	Servicios jurídicos	(69)
		Estudio de mercado, realización de encuestas de opinión pública	(73)
	F	Servicios auxiliares a los servicios de seguros	(66)
	O	Servicios relacionados con juegos de azar y apuestas	
F	H-T	Servicios de telefonía móvil	(61)
	F	Intermediación monetaria	(64)

Una forma de entender mejor qué características diferenciales estarían reflejando cada uno de los clusters conformados consiste en analizar las medias de cada conglomerado para las distintas dimensiones consideradas, en este caso, los cinco componentes principales estimados previamente. Como puede apreciarse en el gráfico 2, el cluster A presenta varias dimensiones en torno o levemente por debajo del cero (que, en cierta medida, representa al promedio general). Otra cualidad de este conglomerado es que reúne a ramas de SIC procedentes de las cuatro categorías de Eurostat (desde audiovisuales hasta software, pasando por diversos servicios más especializados). Teniendo en cuenta ambos aspectos, sugerimos denominar a dicho conjunto como el *cluster promedio*.

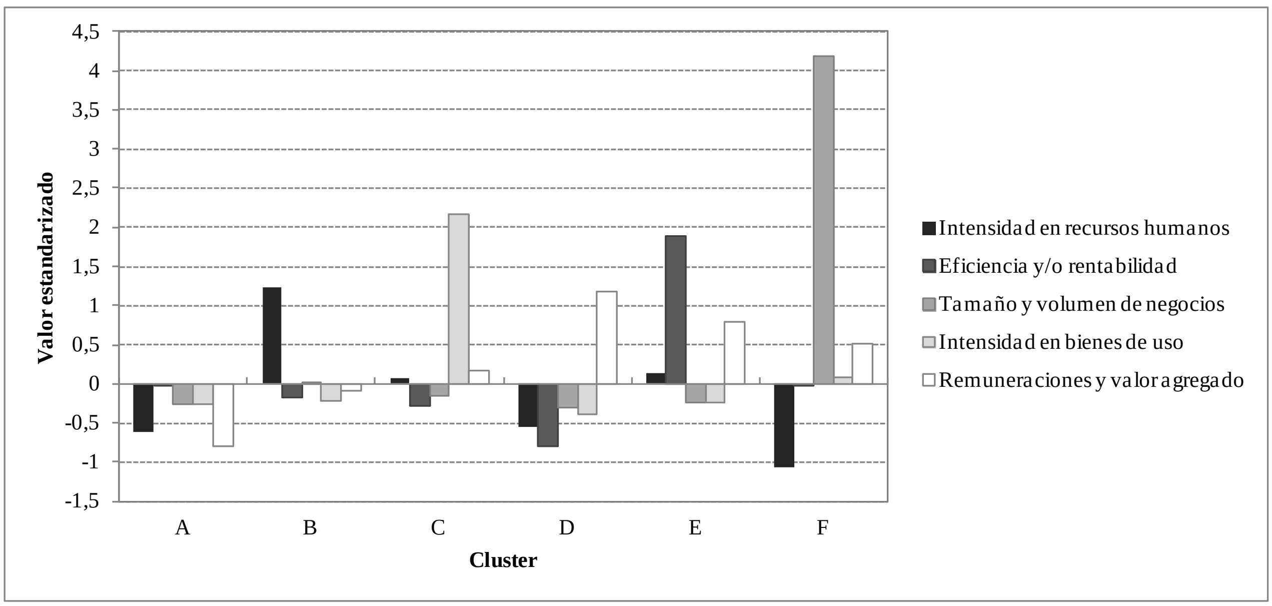
A diferencia del A, el resto de los clusters se distingue positivamente en alguna (o algunas) de las cinco dimensiones de análisis. Por ejemplo, el conglomerado B exhibe la mayor intensidad en recursos humanos de todos los clusters, mientras que en el resto de los componentes principales se encuentra muy próximo al cero. Este conglomerado incluye algunas ramas *high-tech* en donde se emplea personal altamente especializado (como I+D e ingeniería) pero también otras que se caracterizan por el empleo intensivo de mano de obra de nivel medio de calificación (e.g. *call centers*). En una caracterización general, se trata de actividades en donde la expansión o achicamiento de los negocios va muy pegada a movimientos similares en la dotación de personal. Por ello, denominados al cluster B como *SIC intensivos en recursos humanos*.

En el caso del cluster C, la característica dominante es la alta intensidad en la utilización de bienes de capital. Esta es una particularidad esperable entre ramas de telecomunicaciones o televisión, que dependen fuertemente de redes de infraestructura, como así también en el caso de los servicios deportivos y de esparcimiento, donde lo edilicio juega un papel importante. Denominamos a este conjunto como *SIC intensivos en bienes de uso*.

Por su parte, el cluster D también responde a una lógica clara, ya que aglutina a los distintos servicios de transporte y a buena parte de los servicios financieros, todos sectores en donde, como es conocido, las remuneraciones salariales promedio son elevadas. Esto puede reflejar en ciertos casos la calificación del personal respectivo, pero también las particulares condiciones de negociación laboral en ramas que desarrollan actividades de alto impacto social y económico y están altamente reguladas desde la política pública. A este cluster lo designamos como *SIC con alta remuneración al personal*.

En el caso del cluster E vuelve a aparecer la particularidad de reunir ramas de todas las categorías definidas por Eurostat. La otra característica sobresaliente de este grupo es la mayor eficiencia y/o rentabilidad con respecto al resto de los conglomerados, que va de la mano de la existencia de altas remuneraciones promedio (no sorprendentemente, los niveles de valor agregado por ventas y empleado son también elevados). Cabe destacar además que, salvo en el caso de la rama *estudios de mercado*, se trata de sectores sujetos a regulaciones públicas en materia de precios-tarifas y acceso al mercado. Proponemos denominar al cluster E como *SIC de alto valor agregado y rentabilidad*. Por último, el cluster F se compone de sólo dos sectores de servicios cuya particularidad principal pasa por el gran volumen de sus operaciones y niveles de empleo: los servicios de telefonía móvil y los servicios bancarios. Se trata de dos casos de *SIC de gran tamaño y volumen de actividad.*

Gráfico 2. Medias de los clusters en cada dimensión



5. Reflexiones finales

Al presente no hay dudas de que el sector servicios, tal y como está definido en las clasificaciones estadísticas estándar, reúne a actividades muy diversas entre sí. Sin embargo, la literatura es menos clara acerca de si esto también se refleja hacia el interior de un conjunto de actividades conocidas como *servicios intensivos en conocimiento*, los cuales han atraído un interés creciente debido al papel que pueden jugar en el desempeño y la productividad del resto de las actividades económicas y en la generación y difusión de nuevo conocimiento.

En la revisión bibliográfica se destacó que algunos trabajos consideran que los SIC tendrían características relativamente homogéneas, mientras que varios aportes empíricos se limitan únicamente a comparar los SIC con el resto de los servicios o, en el mejor de los casos, a dividir a los SIC en algunas categorías agregadas. Los resultados del presente artículo, si bien preliminares y con diversas limitaciones, muestran que al trabajar con datos más desagregados la apariencia de homogeneidad tiende a desaparecer y surgen una serie de características o dimensiones heterogéneas entre los distintos sectores considerados intensivos en conocimiento. Esta contribución empírica se apoya en la utilización de datos sectoriales a tres dígitos de desagregación, en contraste con el grueso de la literatura (e incluso de la clasificación de Eurostat) que se basa en información a uno o dos dígitos y, por ende, excluye la posibilidad de identificar diferencias entre los subsectores allí agrupados. Por otro lado, en lugar de trabajar con una tipología teórica definida *ex-ante*, se buscó abrir la *caja negra* de los SIC y utilizar técnicas de análisis multivariado para que los diferentes patrones, en caso de existir, surjan *ex-post* de los propios datos. No son muchos los estudios que hayan realizado un ejercicio de esta naturaleza, y menos aún en el contexto de países en desarrollo como los latinoamericanos.

Dicho esto, cabe destacar, no obstante, que lejos estamos de haber querido presentar una tipología *definitiva* de los sectores de SIC. Como hemos señalado, en la literatura abundan los criterios y las clasificaciones, lo que en cierta medida responde además a la disponibilidad de diferentes fuentes de información (de distintos países y/o con diversos sectores, variables, etc.) como así también a las metodologías utilizadas. En este caso, si bien la evidencia resulta novedosa para un país en desarrollo como la Argentina, quedan varios aspectos pendientes que pueden dar pie a futuros trabajos. Uno es que al trabajar con promedios sectoriales se pierde de vista la posible heterogeneidad entre las firmas que componen cada sector, por lo cual habría que intentar acceder a información a nivel de empresa. Por otro lado, si bien la información tributaria disponible permite trabajar con indicadores económicos, productivos y/o financieros tradicionales, queda un espacio todavía para aportar a otras discusiones comunes en la literatura como, por ejemplo, si los distintos clusters presentan a su vez patrones de innovación diferentes.

Por último, y de cara al diseño e implementación de políticas para el sector servicios y, más específicamente, para los SIC, este artículo llama la atención respecto de la necesidad de tomar en cuenta la heterogeneidad inherente a las actividades desarrolladas y a las diferentes realidades empresariales en los distintos subsectores. Este paso ayudaría a direccionar mejor los esfuerzos públicos dirigidos a promover estas actividades, siendo que, al presente, los SIC podrían jugar un rol central en los procesos de desarrollo en el mundo emergente.

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Does Investment in Advertising Boost Economic Performance? Firm-Level Evidence of Ecuadorian Manufacturing

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Abstract: This paper examines how the firm´s advertising investments are related to different measures of economic and productivity performance during 2007 – 2017 in Ecuadorian manufacturing. Particularly, this study analyzes if firms that have advertising investments have better economic and productivity performance compare to non-advertising investment firms. In addition, this looks for evidence on how the different advertising strategies may affect productivity and gross revenue in both advertising and non-advertising firms. For this, this paper estimates the total factor productivity (TFP) at firm-level using a semi-parametric approach to reduce the simultaneous and endogeneity problems in the selection of inputs. The estimation results show that manufacturing firms which invest in advertising have an *Advertising Premia* on economic and productivity indicators, this premia is higher on economic outcomes. Also, the findings are that continuing advertising investment strategy firms have higher TFP, labor productivity, and gross revenue than exiting advertising investment firms, suggesting self-selection in the exit side of the market but not in the entry side of the market. Finally, the study finds that after firms entering to invest in advertising, firms experience an improvement on TFP, labor productivity, and gross revenue growth, which are in favor of learning by advertising hypothesis.

Keywords: Productivity; advertising; firm strategy; intangible capital

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1. Introduction

Firms usually seek to have economic returns/profitability to be able to remain and growth in time. In this long-run objective, they invest in tangible and intangible assets/capital, so that, from this firm's assets/capital, they can operate and produce a good/service that is consumed by the market in which it operates. It is well known that firms that invest in tangible assets/capital, such as machinery and equipment, new factories, and others, do so to increase the production level and thus increase their sales, profitability, and, if possible, market share. However, investments in intangible assets/capital such as Research and Development (R&D), patents, intellectual property rights, trademarks, goodwill, advertising, and others, may lead to generate the same profitability, sales, productivity and growth levels in market share, see for example: (Corchón & Marini, 2018; Hall, Mairesse, & Mohnen, 2010; Lev, 2005). In this final line, Bontempi & Mairesse (2015) find that intangible capital represents more than four times the productivity gains of tangible capital, similar results are found by Crass & Peters (2014) where intangible assets, especially R&D, advertising spending and human capital, improves business productivity.

Advertising spending, as part of the investment in firm intangible assets, is important because it might attract new consumers and also retain current consumers. Aaker & Myers (1987), Kirmani & Zeithaml (1993) mention that advertising investments also increases differentiation and awareness; Mizik & Jacobson (2003), Frieder & Subrahmanyam (2005) argue that this expenditure creates brand equity, an intangible market-based asset, Fombrun, Gardberg, & Barnett (2000) state that it also increases reputational capital and this will positively affect the creation of brand equity. In addition, much evidence suggests that this investment has a positive effect on a firm's market value (Connolly & Hirschey, 1984; Salinger, 1984; Chauvin & Hirschey, 1993; Joshi & Hanssens, 2010; Luo & de Jong, 2012).

In this line, firms invest in advertising not only for the mentioned above but also because it could increase sales, profitability, and productivity. Joshi & Hanssens (2010) mention that "a higher profit in one period may lead to increased advertising budgets, which in turn may boost sales and future profits". If firms start to obtain greater profits, it probably creates an increase in economic performance by investing in new technologies, for example. This increase may lead to generate a greater labor supply. Therefore, an optimal selection of productive factors such as labor and capital will make firms more productive. Also, Chauvin & Hirschey (1993) mention that spending in advertising can be viewed as a form of investment in intangible assets with predictably positive effects on future cash flows. Nevertheless, they suggest that the potential in the effectiveness of advertising expenditures depends on firm size.

In this line, Chen & Waters (2017) argue that a highly productive firm may be able to extend its market share with advertising. Overall, the effects of advertising investment in economic performance not only depend on the intensity of the expenditure as the seminal research developed by Dorfman & Steiner (1954), it also depends on other variables such as: firm size, location, foreign direct investment (FDI) flows, economic sector, and strategies of advertising investments. In addition, firms that invest in advertising create expectations in their consumers, and their demand could rise (Jaumandreu & Mairesse, 2017), in turn, to satisfy the increase of demand the firms need to be more productive in order to expand their supply and compensate

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the emerging demand. Dorfman & Steiner (1954) analyze how a firm can influence the demand for its products to maximize its profits by choosing the price and the amount of its advertising budget. However, decisions about advertising investment are related to productivity and economic performance in a two-way relation.

Contributing to this empirical debate, this paper gives new insights into the effect of investments in advertising and various measures of productivity and economic performance in the Ecuadorian manufacturing sector during 2007 – 2017 using an underexplored and novel firm-level data. Although, this causal relationship has been studied in developed countries (specifically with a set of intangible assets), scarce evidence has been obtained in developing countries and nothing for Latin American firms.

Ecuador is used as a case study, particularly since it is a dollarized country and where the investment in advertising of manufacturing firms is relatively high since more than 70% of companies throughout the industry invest in advertising during the period 2007 – 2017. Additionally, the investment in advertising can be seen as an investment in intangible assets that promotes the innovation of a product and that in its effect can produce increases in productivity and economic performance; also as innovation in marketing which refers a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing (OECD, 2005), this final concept is scarce addressed in emerging and Latin American economies, because scarce literature analyze this problematic (advertising – productivity) in economic aspect. On the other hand, and generally, advertising has been focused as an expense in most developing countries (contrary to the OECD concept), in this study it is analyzed as an investment in the short and medium-term.

First, this paper determines the advertising premia in firm performance using a firm-level dataset of Ecuadorian manufactures from 2007 – 2017, whereas many previous studies in other countries have employed industry-level data. The data used is obtained from the "Superintendencia de Compañías, Valores y Seguros del Ecuador (SCVS)" which is the supervisory institution of all companies in Ecuador, for this study uses all the manufacturing firms. Second, it estimates the total factor productivity (TFP) to determine the advertising premia on TFP, and then we compare this premium with labor productivity and gross revenue. The TFP is estimated using parametric and semi-parametric techniques. We prefer Levinsohn & Petrin (2003) estimator, which reduces the endogeneity and simultaneity in the selection of the inputs. Finally, the paper proposes the analysis of advertising investment strategies close to Fariñas & Martín-Marcos (2007) approach where they use exports strategies, this novel form of studying the advertising investments would help to interpret in a better way which firms have better productivity and economic performance depending on their advertising strategies over time.

In this context, the research objectives are to determine if firms that have advertising investments, measured as marketing innovation similarly to OECD (2005), have better economic and productivity performance compare to non-advertising investment firms. Also, this paper looks for evidence on how the different advertising strategies may affect productivity and gross revenue in both advertising and non-advertising firms.

The structure of the document is as follows: Section 2 shows the literature review and hypotheses; section 3 reviews the methodology and data; section 4 shows the empirical results and discussion; finally, section 5 gives final remarks.

2. Literature Review and hypotheses

Research on the effect of advertising investment has focused particularly on the relationship between profitability and sales, although these variables are used as business performance. Studies regarding the relationship between advertising investment and productivity are scarce; mostly, it has been made as an intangible asset where it is included as brand capital, marketing capital, or even as R&D.

Many studies find that firms which invest in advertising show a positive effect on their performance and profitability (Comanor & Wilson, 1974; Porter, 1974; Lambin, 1976; Kirmani & Wright, 1989; Erickson, 1992; Leone, 1995; Mela, Gupta, & Lehmann, 1997; Osinga, Leeflang, Srinivasan, & Wieringa, 2011; Chen & Waters, 2017). However, there are also other studies testing the relationship between advertising and firm performance, that are unable to find a clear direction of the relation (Erickson & Jacobson, 1992; Han & Manry, 2004; Joshi & Hanssens, 2009). Besides, there are a few studies that have found no relation between advertising investment and sales performance (Kihlstrom & Riordan, 1984; Milgrom & Roberts, 1986; Mesak, 1992; Hanssens, Parsons, & Schultz, 1999; Ali Shah & Akbar, 2008)

In this line, although it may seem obvious that firms invest in advertising to improve their performance and specifically sales and profitability, this does not always happen, particularly because the effects of this investment are not always accompanied by goods improvements, training of employees, labor and business productivity, among other facts. Authors like Narayanan, Desiraju, & Chintagunta (2004), Kremer, Bijmolt, Leeflang, & Wieringa (2008), Osinga, Leeflang, Srinivasan, & Wieringa (2011) refer that advertising does not necessarily generate an expected sales return, rather it has a moderate influence on short- and long-run sales; the advertising investment takes time for the results to be noticed within-firm performance, it is an adaptive learning process, Hoberg & Phillips (2016) mention that this could be associated with a later differentiation of the competition which after a while can be translated into profitability; this differentiation with competitors could create endogenous entry barriers as mentioned by Sutton (1991).

It is also important to mention that not all firms have the same returns in advertising investments. Assaf et al. (2015) argue that the link between advertising investment and firm performance is not simple, and, assuming that there are no other variables interacting with this relationship is unrealistic. In this line, firm size is an important variable when analyzing the impact of advertising investments on firm sales and profitability. Another important relationship beyond investment in advertising is the intensity of this investment. Thus, Assaf, Josiassen, Mattila, & Cvelbar (2015), Sun (2014), Eng & Keh (2007), Chauvin & Hirschey (1993) found that large firms tend to be advertising-intensive and get better returns in advertising than smaller firms.

However, Dorfman & Steiner (1954) in their theoretical model, suggest that the advertising-sales ratio equals the product of the price-cost margin and the advertising elasticity of the demand. In this sense, firms need to decide their advertising budget in terms of sales percentage to obtain profits. Martin (1979) takes advantage of this model and shows that the decisión of advertising investment also depends on both profitability and market concentration at the same time, which can be characterized as a quasi-simultaneous decision. Also, he found that firms with a high advertising-sales ratio have better profits. Conversely, Netter (1982) shows that advertising reduces the profitability returns of those firms that advertise intensively.

Other variables affecting advertising investment, and its intensity, are the market size and market growth, for example, firms need to strengthen their advertising strategy when they operate in growing trend markets with a competitive structure[1] . Mavrommati & Papadopoulos (2005) found that the factors that affect the elasticity of advertising are expected to influence the advertising intensity as well; these factors are associated with the demand, product differentiation, and market conditions.

Jaumandreu & Mairesse (2017) show the effects of product and process innovation in firms' productivity in which they found that the advertising variable augments the demand significantly. However, if they exclude this advertising variable from the cost equation, they found that there are no significant changes in the marginal cost function, concluding that the effect of advertising upon productivity is indirect. In this sense, the effect of advertising affects not only the current demand but also the future demand, future market share, and profits (Chauvin & Hirschey, 1993; Baye, Jansen, & Lee, 1992), which in the end may improve labor and business productivity, in other words the TFP.

Studies related to business productivity and advertising investment are scarce; the closest to the productivity-advertising relationship is when advertising investment is treated as an intangible asset, specifically when this asset is the sum of R&D and advertising. Corrado, Hulten, & Sichel (2005) take advertising investment as a brand equity component under the economic competencies group and found that advertising investment is 0.023 times the GDP in the US. This has been the first attempt to include intangible assets as part of the national accounting measurement, and also the first time advertising is treated as an investment and not as an expense. Based on this, Corrado, Hulten, & Sichel (2009) found that the contribution of intangible capital to growth in labor productivity is about the same as the contribution of tangibles, in addition, the capitalization of intangibles increases the rate of growth of output per hour in both the 1973–95 and 1995–2003 periods. In the same line, Crass, Licht, & Peters (2015) found that growth in branding capital (as advertising) was associated with a relatively smaller increase in labour productivity growth, it was roughly 0.03 percentage points in manufacturing, utility, and agriculture & mining, and more or less negligible in the other sectors; Niebel, O'Mahony, & Saam (2017) found that intangible assets, including advertising, in the European Union (EU) countries have a positive impact on labor productivity, especially in manufacturing sectors.

In terms of TFP, Crass & Peters (2014) found for German manufacturing and services firms that branding capital was positively related with TFP and the magnitude was similar compared to investments in R&D, implying that advertising investment increases the business productivity, they also found that branding capital turns out to be positively related to productivity in all manufacturing and service industries. Furthermore, Bontempi & Mairesse (2015) included advertising investments into the intangible capital group and mentioned that advertising is the most important of these intangibles; they found that customer capital, which includes advertising investment, is the highest contributor to the TFP in the Italian manufacture market.

In summary, the relationship between advertising investment with sales, business performance, and profitability has been studied in a large majority, although the authors have different criteria on the impact of advertising on economic performance. There are certain similarities such as time is an important factor at the moment to know if it really improves economic performance when the advertising investment is incurred. However, the relation advertising investment and TFP has been little investigated, only focused on intangible assets without showing specific results of the *pure* effect of advertising investments.

In this sense, this paper seeks to fill this gap in the literature not only by finding the *pure* effect of advertising investments on productivity, labor productivity, and gross revenue. In addition, this paper explores *premias* of advertising investments on various economic performance variables, and finally, this study contributes to the existent literature by studying how advertising investments strategies can impact two measures of productivity and its growth rate, and also gross revenue; in addition, we use Ecuador as emerging country since scarce literature on this topic have been studied developing countries and only have focused on developed countries.

Likewise, the paper contributes to the management literature in the sense that not only the effect of advertising investment on economic performance is analyzed, but also, the advertising investment variable being a business and endogenous decision, is the exogeneizes in such a way that different business strategies in advertising investment are analyzed and how these decisions can affect not only productivity and sales but their growth rates in the short and medium run.

We, therefore, formulate the following four hypotheses:

H1: Investments in advertising have a positive relationship with economic and productivity performance; therefore, there is an *Advertising Premia.*

[1] Conversely, advertising investment may not be necessary under a perfect competition structure as all goods are homogeneous (Tirole, 1988; Sutton, 1991).

H2: The productivity level is positively affected by advertising investments in such a way that firms that invest in advertising have higher TFP than non-advertising investment firms.

H3: There is self-selection and learning by advertising to invest in advertising since firms adopt different strategies to boost productivity and gross revenue.

H4: Investments in advertising could have a lag effect on economic performance, specifically on sales and productivity.

3. Empirical Methods

3.1. Data Structure

We use a unique and novel unbalanced panel data from 2007 to 2017 (annually) built with all the population of Ecuadorian manufacturing formal firms, this dataset was constructed from the balance sheets and financial statements registered in the official website of the Superintendencia de Compañías, Valores y Seguros del Ecuador (SCVS) (2018) which is the company supervisory institution in Ecuador[2].

The dataset provided by the SCVS contains information on firm-level characteristics, geographical location (region, state, and city); industry location (ISIC two Digits to ISIC six digits) in Table 1A I show the 24 ISIC codes according to the manufacturing industry; economic and financial accounts of all formal manufacturing firms. Those characteristics of data allow getting information on gross revenue, net tangible assets, investments, number of formal employees, domestic raw material purchases, foreign raw material purchases and imports, all measures in real values[3], size measured as an amount of gross revenue and/or number of employees[4]. Also, the dataset contains information about other important accounts such as: expenditure in advertising, if the firm receives Foreign Direct Investment (FDI) on each year, wages, gross profit, and others. Which those variables it is possible to construct some indicators like labor productivity, capital productivity, wages per hour.

The panel data contains 31,064 observations, and 5,371 formal manufacturing firms during 2007 – 2017. This information is given by depuration criteria similar to Camino-Mogro, Armijos-Bravo, & Cornejo-Marcos (2018) where firms that had reported values less than or equal to 0 in gross revenue, number of workers, total fixed assets and consumption of raw material were eliminated. Also, firms that had reported the number of workers but zero values in wages were eliminated too. Finally, firms that are not active in each year of analysis were eliminated because the supervisory institution does not have the financial statement and balance sheet.

Table 1 shows the definition of each variable included in the analysis. The variables description was made based on the established by the SCVS on its accounts catalog of the Ecuadorian firm system. Besides, Table 1 shows the mean values for several firm characteristics. The comparison is divided into three groups, advertising spending firms, non-advertising spending firms by size: Micro, Small and Medium (MSME), and large firms, also all firms since 2007. The dataset allows dividing the firms into different strategies that companies have done in terms of advertising investments during the whole period. In this path, firms can be classified into five strategies group: Continuing advertising investments, Entering advertising investments, Switching advertising investments, Exiting advertising investments, Non-advertising investments. Firms investing in advertising the whole period is defined as continuing advertising investments; firms that entry to invest in advertising during the period without further changes in their strategy is defined as entering advertising investments; on the contrary, firms that stop to invest in advertising during the period without further changes in their strategy is defined as exiting advertising investments; firms that switch their advertising investments more than once in the whole period are defined as switching advertising investments; finally, the non-advertising investments corresponds to firms not invests in advertising in all the period.

Table 1 shows the difference between advertising investment firms and non-advertising firms. The main differences between those groups are in terms of size since the disparity is substantial in gross revenue, employment, capital stock, and raw material consumption. The difference in gross revenue is approximately 8.5 times more in advertising investment firms, in employment is 5.6 times, in capital stock is 8.5 times, in raw materials consumption is 7 times and in gross profit is 16.9 times more than their counterparts.

In addition, in productivity indicators, this pattern continues; however, it is slightly lower than for output and input variables. On average, advertising investment firms have more Labor productivity, TFP, Capital per hour (CPH), and wage per hour (WPH) than non-advertising firms. This relation is persistent across firm size; for example, advertising investments large firms have higher labor, total factor productivity, CPH and WPH in the Ecuadorian manufacturing industry compared to non-advertising investment firms. In this line, managers need to know the magnitude of the advertising premia on labor, capital, and TFP, since productivity may be related to economic firm growth.

Table 1 also shows the difference between advertising investment firms and non-advertising firms in terms of large and MSME firms. Again, in mean, advertising investments, large firms, and MSME have larger economic and productivity performance than their counterparts. For example, advertising investments large firms have 1.7 times more gross revenue, employment, capital stock, and raw materials than their counterparts. This suggests that investments in advertising also require more employment, assets, and raw materials to increase production. A similar pattern is showing on MSME firms.

[2] sheets and financial statements year after year until the month of April of the following year, those companies that for two consecutive years do not deliver their balance sheets and financial statements to the SCVS are sent to a declaration process of inactivity to then go to a dissolution process.

[3] The Gross Revenue and Raw Materials are deflated using industry-specific price index obtained from the Ecuadorian National Institute of Statistics.

[4] Firm size is defined in the Organic Code of Production, Trade and Investment of Ecuador: Microenterprises: Between 1 to 9 workers or revenue less than $ 100,000.0. Small firms: Between 10 to 49 workers or revenue between $ 100,001.0 and $ 1,000,000.0. Medium firms: Between 50 to 199 workers or revenue between $ 1,000,001.0 and $ 5,000.000.0. Large firms: More than 200 workers or revenue above $ 5,000,001.0. Always prevailing revenue over the number of workers.

In Annexes, Table 2A, we show the evolution of the number of firms that invest in the advertisement, by two-digit ISIC, in percentages for the Ecuadorian manufacturing industry for the period 2007-2017. In Table 3A, we present the total number of firms by year and two-digit ISIC including Advertising Investments and non-advertising investment Firms. We also show that the number of firm's investments in advertising is not constant over the years by the manufacturing sector; nevertheless, Table 4A shows that more than 50% of all manufacturing firms invest in advertising in each year. Finally, Table 5A shows the firm´s distribution by region; the Costa and Sierra regions are the more representatives, with 42 and 57 percent of firms respectively. The rest of 1 percent is in Oriente and Insular region.

Table 1. Variables definition and mean characteristics for Advertisers and Non-advertisers. (Advertisers are defined as continuing and entering advertisers over the whole period)

Variable	Description	All Firms		Large Firms		MSME Firms	
		Advertising spending	Non-advertising	Advertising spending	Non-advertising	Advertising spending	Non-advertising
Gross revenue (000$)	Total income from sales = Revenues from sales of ordinary activities of the company (income from extraordinary activities is excluded from the business of each firm, for example: land sales, machinery, etc.).	14,700.0 (9,597)	1,727.1 (5,768)	41,700.0 (3,313)	24,200.0 (655)	1,363.9 (6,284)	407.1 (5,113)
A/S	$\frac{\text{Advertising Spending}}{\text{Gross revenue}}$	0.03 (9,597)	-	0.02 (3,313)	-	0.04 (6,284)	-
Employment	Number of legally registered employees.	124 (9,597)	22 (5,768)	319 (3,313)	188 (655)	28 (6,284)	10 (5,113)
Capital Stock[5] (000$)	Net tangible assets = the sum of the real dollar value of buildings, machinery, and vehicles, assuming a depreciation of 5, 10, and 20 percent, respectively, similar to: Añón Higón, Gómez, & Vargas (2017), Bravo-Ortega, Benavente, & González (2014). $k_{it} = (1-d)k_{it-1}\frac{P_t}{P_{t-1}} + I_t$	4,719.9 (9,597)	550.4 (5,768)	13,500.0 (3,313)	7,524.3 (655)	341.4 (6,284)	260.5 (5,113)
Raw Materials (000$)	Imports of raw material + local net purchases of raw material + transport expense + fuel expense + spending on office supplies + expenditure on maintenance and repair + basic services expenditure (water, energy and internet).	8,982.3 (9,597)	1,286.8 (5,768)	25,800.0 (3,313)	14,500.0 (655)	646.3 (6,284)	181.5 (5,113)
Labor Productivity	$\frac{\text{Gross revenue}}{\text{Employment}}$	3.4 (9,597)	2.8 (5,768)	4.2 (3,313)	4.5 (655)	3.1 (6,284)	2.5 (5,113)
Total Factor Productivity	Levinsohn and Petrin (2003) Production function estimates: $\hat{a} = y_{it} - \hat{\alpha}k - \hat{\beta}l - \hat{\gamma}m$	8.8 (9,597)	8.0 (5,768)	9.8 (3,313)	9.7 (655)	8.4 (6,284)	7.8 (5,113)
Capital per hour[6]	$\frac{\text{Capital stock}}{\varpi}$	1.5 (9,597)	0.8 (5,768)	2.6 (3,313)	2.4 (655)	1.0 (6,284)	0.5 (5,113)
Wage per hour	$\frac{\text{Wages Expenditure}}{\varpi}$	1.3 (9,597)	0.9 (5,768)	1.5 (3,313)	1.1 (655)	1.1 (6,284)	0.8 (5,113)
Gross Profit (000$)	Profit before taxes	913.0 (9,597)	54.0 (5,768)	2,731.9 (3,313)	871.5 (655)	38.9 (6,284)	8.8 (5,113)

Notes: Values in brackets are the number of observations per subsample.

[5]We measure the Capital stock with the Gross Investment in equipment in year t (I_{it}), net fixed assets in real value (physical capital in year *t-1*) (k_{it-1})), a depreciation rate (*d_it*) and the price index for equipment at the industry level (P_t) obtained from the Ecuadorian National Institute of Statistics. This measure is also used in Camino (2017), Fariñas, López, & Martín-Marcos (2014), López (2014), Echavarría, Arbeláez, & Rosales (2006). Similar to Añón Higón, Gómez, & Vargas (2017) I estimate the stock of physical capital, with the initial stock (k_0): $k_0 = (1-d)^{VM}\, TFA_0 \frac{P^0}{P_{0-VM}}$, where TFA is the value of total fixed assets, VM is the average age of a firm´s fixed assets.

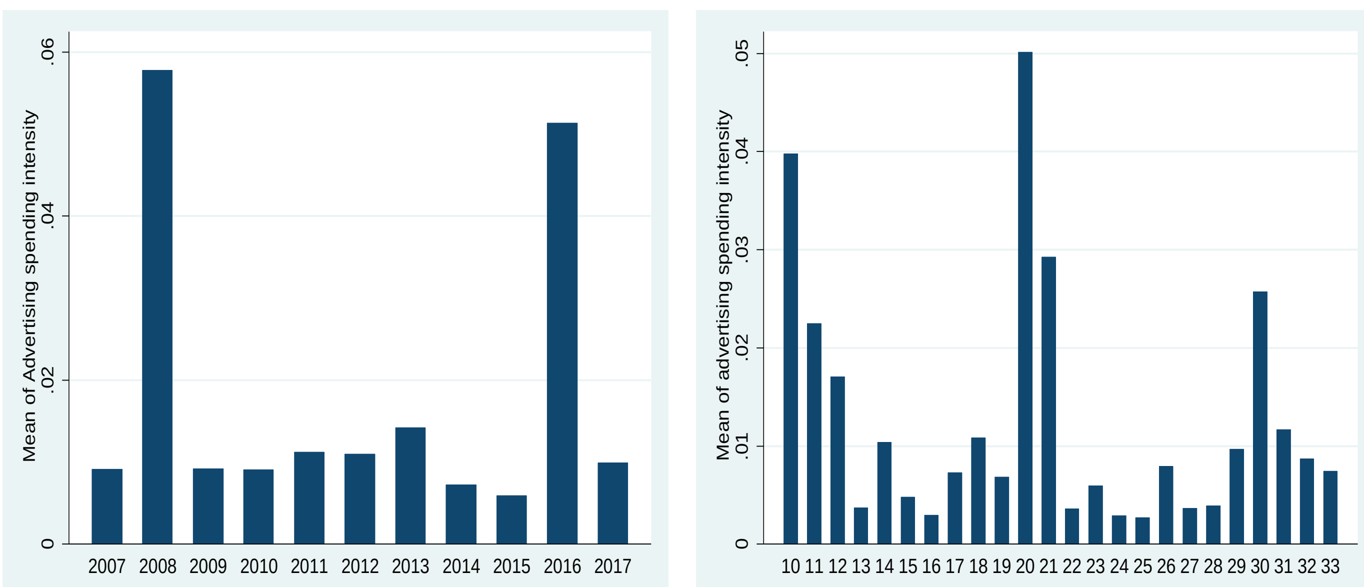
[6] ϖ is the annual effective worked hours. I pondered a mean of 2086 hours worked per employee.

In Figure 1, we show the mean of advertising investments intensity by year, in 2008 firms invested a little more than 5% in advertising as a ratio of gross revenue, likewise 2016 are the only year in which firms in the manufacturing industry invested, on average, more than 4% of their gross revenue in advertising, the other years this ratio is less than 2%. This evidence is in concordance with Srinivasan, Lilien, & Sridhar (2011) that found that the impact on profits and stock returns of advertising spending during a recession depends on the market share, financial leverage, and product-market profile; however, firms tend to spend more in advertising in recession periods. In Ecuador, 2008 and 2015 – 2016 are considered recession years since the Gross Domestic Product got negative growth rates.

Additionally, in Figure 1, we show the firm intensity of the average investment in advertising for the 24 manufacturing sub-sectors according to the ISIC classification. The subsector that invests most in advertising, as the ratio of gross revenue, is the manufacture of chemicals and chemical products with an intensity of 5%, followed by the manufacture of food products with an average of 4%, and the third subsector that most invests in advertising is the manufacture of basic pharmaceutical products and pharmaceutical preparations with around 3% on average during the 11 years of analysis. The evidence is similar to Sun (2014) who found that good consumer industries are more intensity advertising than industrial goods industries on average.

Coello-Montecel (2017) and Solano-Solano, Camino-Mogro, & Alvarado (2017) found that ISIC 10 and 21, manufacturing subsectors are non-concentrated, but ISIC 26 is highly concentrated in Ecuador during 2013 – 2015; in this line, it is expected that a competitive market invest in advertising to achieve an improvement over competitors and to differentiate themselves from the other firms but in highly concentrated markets advertising spending in many cases may be unnecessary (Comanor & Wilson, 1974; Sutton, 1991; Askenazy, Breda, & Irac, 2016).

Figure 1. Mean of advertising spending intensity



Source: Superintendencia de Compañías, Valores y Seguros
Elaboration: The author

3.2. Econometric Strategy

This study considers a three-stage estimation strategy. First, we determine if firms that invest in advertising have a better economic performance and productivity than those firms that do not invest in advertising, for this we use a simple framework where the average difference between advertising investments firms and non-advertising investments firms are calculated after controlling by size, FDI, industry, time and region. The specification allows capturing the relationship between investments in advertising and a set of firm characteristics; the *Advertising Premia* is estimated from the following equation:

$$ln\Psi_{it} = \alpha + \varrho Advertising_{it} + \lambda Size_{it} + \theta FDI_{it} + \sum_{I} \delta_I Industry_i + \sum_{T} \delta_T Time_t + \sum_{R} \delta_R Region_r + \varepsilon_{it} \quad (1)$$

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Where Ψ_{it} is a vector of economic and productivity characteristics[7] of firm i at time t; $Advertising_{it}$ is a dummy variable that indicates the investment on the advertising of each firm i at time t; $Size_{it}$ is a dummy variable that indicates the firm size (1 if the firm is large and 0 otherwise) of each firm i at time t; FDI_{it} is a dummy variable that indicates if firm i receives foreign direct investment on year t; $Industry_i$ is a set of 24 two-digit ISIC manufacturing industry dummies to control intra-sectorial heterogeneity; $Time_t$ is a set of 11-year dummies from 2007 to 2017 to control macroeconomic shocks; $Region_r$ is a set of 4 region dummies to control geographic firm location; and ε_{it} is an error term. The coefficient is the *Advertising Premia*[8] that firms get on each variable of economic and productivity performance when firm invests in advertising, a positive and significant coefficient represents the *Advertising Premia*, while a negative and significant coefficient shows a penalty for investments in advertising.

In the second stage, this paper estimates the *Advertising Premia* with a Cobb Douglas production function with the traditional inputs: capital, labor, and raw materials. The following equation denotes the specification using industry, time, region and two investments in advertising strategies that are invariant on time:

$$\begin{aligned} y_{it} = \vartheta_k k_{it} + \vartheta_l l_{ti} + \vartheta_m m_{it} + \varrho_1 Advertising_{it} + \varrho_2 Continuing\ Advertising\ Investments_i \\ + \varrho_3 Entering\ Advertising\ Investments_i + \omega_{it} + \sum_I \delta_I Industry_i \\ + \sum_T \delta_T Time_t + \sum_R \delta_R Region_r + e_{it} \qquad (2) \end{aligned}$$

Where y_{it} is the log of the gross revenue of firm *i* in year t, k_{it} is the log of capital stock, l_{it} is the log of labor input and m_{it} describes the log of raw materials; ω_{it} is the firm´s productivity, which includes a mean level of firm efficiency and the deviation of that mean of each firm, in other words, ω_{it} is assumed to be observable by the firm but not by the analyst (Van Beveren, 2012; Van Biesebroeck, 2007; Camino, 2017; Añón Higón, Gómez, & Vargas, 2017; Syverson, 2011). Finally, e_{it} is an error term; *Continuing Advertising Investments*$_i$ is a dummy variable that takes the value of 1 if Firms investing in advertising the whole period; and *Entering Advertising Investments*$_i$ is a dummy variable that takes the value of 1 if firm's entry to invest in advertising during the period without further changes. Since the estimation of a production, the function has been widely debated and has changed over time, from parametric to semi-parametric estimations, we use equation (2) to compare some parametric and semi-parametric methodologies.

In this line, authors like Van Biesebroeck (2007), Van Beveren (2012) and more recently, Bournakis & Mallick (2018) show a survey of differences in each production function estimation methodology. For example, Van Biesebroeck (2007) mentions that the estimation of production functions can be done by parametric or semiparametric methods. Among the parametric methods, we have Ordinary Least Square (OLS); however, it is known that this method has several problems in its estimation. First, the estimated coefficients of the variable inputs will be biased upwards (endogeneity of the inputs). Second, the coefficient of capital will be biased downward (endogeneity of attrition) (Olley & Pakes, 1996). Third, results biased due to a possible difference in the production technologies used by firms (De loecker, 2011). Another parametric method is Fixed Effects and Random Effects, both methods also have some limitations, the fixed effects estimator supposes that the productivity not observed in the production function is constant for each firm, Blundell & Bond (2000) mention that productivity can be decomposed into a fixed effect and an autoregressive component AR (1), in such a way that the assumption of invariability of unobservable heterogeneity is relaxed. Finally, the random effects estimator assumes that the unobservable effect does not correlate with any explanatory variable.

In the same line, Van Beveren (2012) reviewed several production function estimates and compared the two semi-parametric estimations: Olley & Pakes (1996) (OP) and Levinsohn & Petrin (2003) (LP) arguing that both estimations solve the problem of simultaneity and reduce the endogeneity that parametric models can not solve. Nevertheless, the OP estimation only includes firms with positive investments that implies a loss of efficiency and can affect the collinearity between capital and investments (Ackerberg, Caves, & Frazer, 2015).

The prevalence of zero investment observations in many data sets weakens the mapping, prompting Levinsohn & Petrin (2003) to explore an alternative proxy for productivity (material input). In this sense, Van Beveren (2012) argues that if firms report zero investment in a significant number of cases, this casts doubt on the validity of the monotonicity condition; in this vein, Levinsohn & Petrin (2003) use intermediate inputs to proxy for unobserved productivity, rather than investment; this implies that intermediate inputs (raw materials in this case) are expressed as a function of capital and productivity; and the Levinsohn-Petrin (LP) estimator do not incorporate the survival probability and correct for the selection bias. In addition, Van Beveren (2012) mentions that in light of the traditionally poor performance of both the GMM and fixed effects estimators, it would seem that the semi-parametric estimators are to be preferred. Nevertheless, comparing OP between LP estimators, the LP estimator has some advantages from the OP estimator, since this methodology maintains all the observations analyzed and the researcher can retain the full sample of firms in the first stage.

Finally, in the third stage, this paper calculates the TFP at firm-level using the LP estimator. We obtain $\hat{\omega}_{it}$ from the estimated production function. For this, we use the estimated coefficients of each of the inputs, which are, according to the literature on production functions, the most efficient. Thus, we get:

[7] In this study, those interest variables are the ones defined in Table 1, for the exception of (A/S).

[8] As the log approximation underestimates the difference for ϱ To calculate the approximation of the Ψ_{it} increase when firm invest in advertising it has been done with the following expression: $\%\Delta\hat{\beta}_{it} = 100[\exp(\hat{\beta}_{advertising}) - 1]$, see: Wooldridge (2015) for details.

$$\widehat{\omega_{it}} = y_{it} - \widehat{\vartheta_k}k_{it} - \widehat{\vartheta_l}l_{it} - \widehat{\vartheta_m}m_{it} \quad (3)$$

Once the TFP at the firm level is calculated with equation (3), we measure the differences in TFP($\widehat{\omega_{it}}$) between advertising investment firms and non-advertising investment firms. We also divided the variable Advertising $Strategy_i$[9] in a vector of advertising investment strategies that we explain in the *Data Structure* section. In this line, with the specification in equation (4) we explore how the different strategies in advertising show patterns in their productivity performance; furthermore, this new specification allows us to test the selection and learning hypothesis.

$$\widehat{\omega_{it}} = \alpha_0 + \varrho Advertising\ Strategy_i + \sum_{t=1}^{t} \delta_{it}\text{Control Variables}_{it} + \varepsilon_{it} \quad (4)$$

The selection and learning hypothesis has been tested in the majority in international trade (exports and imports) and investments in Research and Development (R&D). This new specification allows testing if more productivity firms select to invest in advertising (selection) and also to test if once firms invest in advertising. After that, they become more productivity (learning). Finally, to correctly test the learning hypothesis we modified equation (4) using as dependent variable the TFP growth ($\Delta\ \widehat{\omega_{it}}$)to get the relationship of entering to invest in advertising and growth of productivity, since investments on intangibles assets could generate later performance improvements as mention Hoberg & Phillips (2016), Bontempi & Mairesse (2015) Luo & de Jong (2012), Hirschey (1982), (Weiss, 1969).

Results

In this section we show the results of *Advertising Premia* controlling simultaneously by region, 2 digits ISIC manufacturing industry and year. In addition, we estimate a parametric and semi-parametric Cobb Douglas production function using the Ordinary Least Square (OLS), Fixed Effects (FE), System Generalized Method of Moments (GMM-SYS) proposed by Arellano & Bond (1991), Blundell & Bond (2000) and the preferred method, Levinsohn & Petrin (2003) (LP) estimator, to obtain the TFP corrected for the simultaneous determination of inputs and productivity, also minimizing endogeneity problems and robust to the Ackerberg, Caves, & Frazer (2015) critique. Finally, we employ a strategy analysis of investments in advertising over the entire period, in order to determine if those strategies increase the TFP, TFP growth, labor productivity, and gross revenue.

4.1. Economic performance differences between advertising investment firms and non-advertising investment firms.

As described above, the main objective of this paper is to get robust evidence that advertising investment[10] firms have better economic and productivity performance than non-advertising investment firms. This procedure involves three steps. Table 2 reports the results from Fixed Effects (FE) regression from manufacturing sector described in equation (1), the results of *Advertising Premia* are obtained by the dummy variable $Advertising_i$ which identifies advertising investment firms within the continuing and entering invest group. Controlling simultaneously by FDI, size, year, two-digit ISIS industry and region, the estimated coefficient ϱ is always positive and suggest that advertising investments are positively and significantly correlated with gross revenue, capital stock, labor, raw materials, gross profit, labor productivity, TFP, CPH and WPH.

This first result shows that there is an *Advertising Premia* in all the economic and productivity variables used on average; the largest difference is found in the economic performance measures. Advertising investment firms are almost 2 times the size of non-advertising investment firms in terms of gross revenue, capital stock, raw materials and gross profit, and 1 time major in employment. In terms of productivity, labor productivity and capital per hour (CPH) are the largest difference between these two groups; we found that advertising investment firms have 38 and 31 percent larger labor productivity and CPH than their counterparts. In addition, total factor productivity (TFP) is 6 percent higher in advertising investment firms; this difference in productivity between advertising investment firms and non-advertising investment firms could be explained by better wages per hour (WPH), advertising investments firms pay 19% better wages than non-advertising investments firms.[11]

In general, firms that invest in advertising are substantially different from firms that not invest in advertising; in this sense, this evidence confirms there is an *Advertising Premia* in all the economic and productivity variables analyzed in this section. This evidence supports the OCDE's (2005) concept, which argues that a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing, could increase innovation and also performance.

[9] This variable is constructed similar to Fariñas & Martín-Marcos (2007) whose propose a decomposition of the export status. I modified that proposal to use the same definition with investments in advertising.

[10] Measured as marketing innovation similarly to OECD (2005) concept.

[11] As the log approximation underestimates the difference for ϱ. To calculate the approximation of the Ψ_{it} increase when firm invest in advertising it has been done with the following expression: $\%\Delta\hat{\varrho}_{it} = 100[\exp(\hat{\varrho}_{advertising}) - 1]$, see: Wooldridge (2015) for details.

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Table 2. The Premium to invest in advertising for various firm characteristics
Advertisers are defined as Continuing and entering advertising investments firms

Dependent variable	Advertising Dummy	Control Variables				
		Size	FDI	*Region*	*Industry*	*Time*
Gross revenue	1.11*** (0.05)	1.34*** (0.05)	0.79*** (0.08)	Yes	Yes	Yes
Capital stock	1.03*** (0.07)	1.16*** (0.06)	1.05*** (0.09)	Yes	Yes	Yes
Labor	0.72*** (0.04)	1.09*** (0.05)	0.43*** (0.05)	Yes	Yes	Yes
Raw Materials	1.32*** (0.07)	1.71*** (0.07)	0.69*** (0.09)	Yes	Yes	Yes
Gross Profit	1.06*** (0.06)	1.84*** (0.06)	1.01*** (0.08)	Yes	Yes	Yes
Labor Productivity	0.32*** (0.04)	0.75*** (0.04)	0.29*** (0.05)	Yes	Yes	Yes
Total factor productivity[a]	0.06*** (0.01)	0.08*** (0.01)	0.05*** (0.01)	Yes	Yes	Yes
Capital per hour	0.27*** (0.05)	0.40*** (0.05)	0.56*** (0.07)	Yes	Yes	Yes
Wage per hour	0.17*** (0.02)	0.26*** (0.03)	0.20*** (0.03)	Yes	Yes	Yes

Notes: Estimates correspond to equation 1. Robust standard errors to heteroskedasticity of estimated coefficients in parentheses. *** indicates the significance at 1% confidence level, respectively. It includes 11-year dummies for the period 2007 – 2017 and 24 industry dummies according to ISIC manufacturing codes. All dependent variables are in log. [a] Total Factor productivity is estimated by the LP method.

4.2. Productivity differences between advertising investment firms and non-advertising investment firms with production functions.

The results obtained in the section above suggest an *Advertising Premia* in all the variables analyzed. In this path, this evidence allows us to continue with the second stage of the econometric strategy, given that in the third stage, we need the estimated coefficients of traditional inputs to get the TFP and get robust evidence between the relationship of investments in advertising strategies of firms.

In this second stage, this paper shows the results of some parametric and semi-parametric production function estimations; the preferred method is the LP estimator. Table 3 provides estimates of the production function of equation (2) using OLS, FE, GMM-SYS, and LP approach; all the methods have positive and significant inputs according to the empirical literature. However, the OLS has overestimated the inputs coefficients of labor and raw materials; surprisingly, the GMM-SYS has underestimated all the effects of input variables. This suggests that those methods have not corrected the simultaneity in the decision of inputs usage and also endogeneity. In this line, we prefer the LP estimator because it includes a correction for the simultaneous of inputs and productivity (Petrin & Levinsohn, 2012).

In Table 3, the results report that the major contributor of traditional inputs to gross revenue is raw materials, followed by labor input and the last is capital stock; this result is similar with other emerging economies like Colombia, Paraguay and Argentina (Hofman, Mas, Aravena, & Fernández de Guevara, 2017; Aquino, 2015; Echavarría, Arbeláez, & Rosales, 2006). Furthermore, the $Advertising_{it}$ variable which is defined as dummy variable which takes the value of one if firm invests in advertising in year *t* and 0 otherwise, is always positive and significant at 1 percent, this suggests that advertising investments firms, on average, have 22 percent higher productivity than those firms that not invest in advertising; this result is quite similar that the obtained in Table 2.

Also, we use two parametrizations of the firm-specific component ϱ_2, ϱ_3 which are continuing and entering advertising investments firms respectively; these variables were done in order to capture the advertising firm's strategy in year *t*, and to get more reliable results with invariant strategies in the whole period, in other words, these strategies allow us to *endogenize* the firm´s decision to invest in advertising as business strategy.

The estimated coefficients of these two parametrizations are positive and significant at 1%; showing that being a continuing investment advertising firm increase productivity in 13% than firms that not invest in advertising, also being entering investment advertising firm increase productivity in 22% on average. In this path, results in Table 3 confirm the *Advertising Premia* on firm productivity and gross revenue.

Finally, the FDI_{it} shows that firms that receive FDI have higher gross revenue than firms who not receive FDI. This result is in concordance with the empirical literature. See for a detailed survey: (Agarwal, 1980; De Mello Jr, 1997; Saggi, 2002). In addition, Sun (2014) found that foreign entry is found to affect positively domestic firms' advertising intensity in the consumer goods industries and affect negatively advertising intensity in the industrial goods industries.

Overall, these results show similar relationships to those found in Table 2; although the effect of advertising investment is positive and significant on the level of output (gross revenue), this second stage only gives a *big picture* of how investments in advertising; nevertheless with output, because of this situation, The third stage will bring a more specific vision of how these investments can be more purely related to productivity and economic measures.

Table 3. Manufacturing Sector
Production Function: Alternative Estimators

Dependent *variable*: y_{it}	OLS (1)	FE (2)	GMM-SYS (3)	LP (4)
k_{it}	0.08***	0.08***	0.02***	0.05***
	(0.01)	(0.01)	(0.01)	(0.01)
l_{it}	0.30***	0.21***	0.06***	0.26***
	(0.01)	(0.01)	(0.01)	(0.01)
m_{it}	0.46***	0.35***	0.14***	0.31***
	(0.02)	(0.01)	(0.01)	(0.02)
$Advertising_{it}$	0.18***	0.17***	0.06***	0.22***
	(0.01)	(0.01)	(0.01)	(0.02)
Continuing Advertising Investment$_i$	0.16***	0.44***	3.01	0.13***
	(0.02)	(0.04)	(4.87)	(0.03)
Entering Advertising Investments$_i$	0.09***	0.18***	12.52	0.11**
	(0.05)	(0.04)	(8.92)	(0.05)
FDI_{it}	0.31***	0.47***	0.20	0.22***
	(0.03)	(0.05)	(0.31)	(0.03)
Instruments	-	-	t-2 and Δ(t-2)	-
Sargan (p-value)	-	-	0.24	-
AR (1) (p-value)	-	-	0.001	-
AR (2) (p-value)	-	-	0.19	-
AR (3) (p-value)	-	-	0.43	-
Year	Yes	Yes	Yes	Yes
ISIC	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes
Observations	31,064	31,064	18,425	31,064

Notes: Estimates correspond to equation 3. Robust standard errors to heteroskedasticity of estimated coefficients in parentheses in columns (1) to (3). ***, ** indicates the significance at 1%, 5% confidence level respectively. It includes 11-year dummies for the period 2010 – 2017, 24 industry dummies according to ISIC codes and 4 region dummies. Advertising is defined as a dummy variable that takes the value of 1 if a firm invests in advertising in year t and 0 otherwise. The GMM-SYS estimator uses the instruments: $y_{it-1},\dots y_{it-3}$,$l_{it-1},\dots l_{it-3}$,$m_{it-1}\dots m_{it-3}$ and k_{it-1} (as predetermined) and also instruments as: $(y_{it-1} - y_{it-2})$,$(l_{it-1} - l_{it-2})$,$(m_{it-1} - m_{it-2})$. The Sargan test is the p-value of the over-identification restriction test of instruments. The AR (1), AR (2) and AR (3) represents the Arellano-Bond p-value, to test that the error of the estimation is not correlated serially with the inputs, in such a way that the null hypothesis is not autocorrelation in at least the second autoregressive process AR (2). The LP estimator is the stochastic process of ω_{it} specifies the third-order polynomials and $Advertising_{it}$ is threat as free variable, bootstrapped standard errors with 250 replications in parentheses are reported.

4.3. Productivity and economic differences by advertising investment strategies.

The third stage of the econometric strategy is to give robust evidence of the causal relationship between measures of productivity and gross revenue with the firm´s advertising investment strategies. The classification about the different strategies that firms could do during the whole period of this analysis allows me to treat this causal mechanism linking advertising investment to productivity and also to test two hypothesis that literature has focused on international trade and R&D like: self-selection and learning by "exporting or doing". Furthermore, differentiation in advertising investment strategies during a period of time allows us to prove more efficiently if advertising investments really improve productivity and economic performance as shown in the previous sections.

In this path, once the production function is estimated with an LP estimator, the TFP is calculated using equation (3). After that, we reparametrize the firm-specific component in equation (4) into a set of four dummies of advertising investment strategies, we improve the interpretation of the estimated coefficients to catch who is who in the market and what strategy is better for productivity performance. In addition, we use the similar approach of Fariñas & Martín-Marcos (2007) to test the self-selection and learning by advertising hypothesis, since to prove those, the estimated coefficient of continuing and entering advertising investment needs to be higher than exiting advertising investment (self-selection hypothesis) and the coefficient of entering advertising investment needs to be positively and significantly related with TFP growth.

Using equation (4) and replacing the variable *Advertising Status*$_i$ with a vector of advertising investment strategies dummies such as: continuing advertising investment firms, entering advertising investment firms, switching advertising investment firms, exiting advertising investment firms and non-advertising investment firms; we obtain the estimated coefficient ϱ for each group by advertising investment status, and we compare the estimated coefficients of each group to test the self-selection and learning by advertising hypothesis. Table 4 reports the results of the estimation mentioned for the Ecuadorian manufacturing sector controlling by size, FDI, year, two-digit ISIC and region.

In Table 4, we found, on average, that productivity of continuing advertising investment firms is positive and higher than non-advertising investment firms being this difference statistically significant. In this line, firms that invest in advertising over all the period analyzed increase their productivity by 9% in the year invested compared to non-advertising firms. According to the self-selection hypothesis, we found that continuing advertising investment firms have higher productivity than exiting advertising investment firms; nevertheless, entering advertising investment firms have similar productivity with exiting advertising investment firms; this result is in favor of selection on the exit side of the market but not in the entry side, since the productivity of entering and exiting advertising investment firms are similar. This result is in line with the argue of Kor & Mahoney (2005) whose mention that a firm's investments in advertising can help it to learn and absorb new knowledge more efficiently, to develop a distinctive innovative capability.

We also find that firms with an entering investment strategy increase their TFP growth in around 6%, suggesting that this strategy not only increases the TFP in the same year but also increases productivity in future years. These results are in concordance with the argue of Narayanan, Desiraju, & Chintagunta (2004), Kremer, Bijmolt, Leeflang, & Wieringa (2008), Osinga, Leeflang, Srinivasan, & Wieringa (2011) whose mention that advertising does not necessarily generate an expected sales return in the same time of the advertising investment, the impact of this investment needs time to change the perception of the consumers and set the differentiation from competitors. In addition, this positive and significant coefficient of entering advertising investment firms with TFP proves the learning by advertising hypothesis. This suggests that start to invest in advertising may improve productivity through this investment.

On the other hand, switching advertising investment firms show a higher TFP (6%) compared to non-advertising investment firms. Finally, we obtain that the average productivity of exiting advertising investment firms is also 6% higher than non-advertising investment firms. It is important to mention that results find a positive relationship and important impacts on TFP level across the different strategies of advertising; previous research has also indicated that strategic entrepreneurship investments, such as those in R&D and advertising and others, positively affect TFP (Urata & Kawai, 2002; Balasubramanian & Lieberman, 2010; Cucculelli & Bettinelli, 2015).

Table 4. Manufacturing Sector
Economic and Productivity performance by advertising investment strategy

	Dependent variable: $\hat{a}_{it}$		*Dependent variable*: *LaborProductivity*$_{it}$		*Dependent variable*: y_{it}	
	TFP level	TFP growth	Labor Productivity level	Labor Productivity growth	Gross Revenue level	Gross Revenue growth
Continuing Advertising Investment$_i$	0.09*** (0.01)		0.60*** (0.05)		1.79*** (0.01)	
Entering Advertising Investment$_i$	0.06*** (0.01)	0.06*** (0.01)	0.47*** (0.07)	0.07*** (0.01)	0.96*** (0.09)	0.14*** (0.02)
Switching Advertising Investment$_i$	0.06*** (0.01)		0.50*** (0.04)		1.14*** (0.05)	
Exiting Advertising Investment$_i$	0.06*** (0.01)		0.52*** (0.06)		1.01*** (0.09)	
Size	0.15*** (0.01)	0.01 (0.01)	1.09*** (0.04)	0.01 (0.01)	3.15*** (0.005)	0.04*** (0.01)
FDI	0.02*** (0.01)	-0.01 (0.01)	0.14*** (0.04)	-0.01 (0.01)	0.38*** (0.05)	-0.01 (0.01)
Year	Yes	Yes	Yes	Yes	Yes	Yes
ISIC	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes
Observations	31,058	23,828	31,064	23,828	31,064	23,828

Notes: Estimates correspond to equation 6. Robust standard errors to heteroskedasticity of estimated coefficients in parentheses. *** indicates the significance at 1% confidence level. Advertising status is decomposed into four dummies: continuing, entering, switching, and exiting advertising being the reference category non-advertising spending firms. We apply a set 24 industry, 11 time and 4 region dummies. TFP, Labor Productivity, and Gross Revenue levels are in logs.

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In terms of labor productivity, Table 4 shows similar but higher estimated coefficients on each advertising investment strategies. Also, the self-selection on the exit side of the market is confirmed but not on the entry side of the market. According to the learning by advertising hypothesis, we confirm that entering advertising investment firms have higher labor productivity growth than non-advertising investment firms, suggesting that there is a learning process that enables the improvement of productivity.

Finally, we found that advertising investment strategies have a higher pattern on the causal relationship with gross revenue. The results of each strategy are significantly higher comparing with the other measures of productivity; nevertheless, this pattern is the expected, since the supporting evidence of advertising accountability and the processes would make advertising spending more "essential to firm organic growth" (Gupta & Steenburgh, 2008), and the benefits induced by advertising, in turn, boost future sales and profits of the firm (Chen & Waters, 2017; Osinga, Leeflang, Srinivasan, & Wieringa, 2011).

These advertising investment strategies throughout the analyzed period show us the impact of each strategy on productivity and gross revenue, mainly showing us that investing is not the same as investing at random or spending a year or several to obtain an improvement in the productivity and also in the productivity growth. Advertising investment allows firms to improve their productivity and gross revenue growth rates, which in the medium and long run will lead them to obtain better economic performance.

4.4. Robustness Check: the lag effect of advertising investments on economic performance

Authors like Narayanan, Desiraju, & Chintagunta (2004), Kremer, Bijmolt, Leeflang, & Wieringa (2008), Osinga, Leeflang, Srinivasan, & Wieringa (2011) and others, argues that investments in advertising could have a lag effect on economic performance, specifically on sales and productivity, and this effect often becomes observable only after some time. In this line, we employ a robustness check in Table 5 using the same measures of productivity and gross revenue as dependent variables and the *Advertising Investment*$_{it-n}$ as independent variable, controlling by size, FDI, industry, year and region.

The *Advertising Investment*$_{it-n}$ capture the effect of lag 1 and lag 2 on TFP, labor productivity, gross revenue, and growth rates. The results in Table 5 are quite similar to those obtained in Tables 3 and 4; the effect of the second lag of advertising investment is always lower than the effect of the first lag on productivity and sales measure. This evidence is in favor of the authors mention above and also suggests that the effect with time decreases; other authors suggest that the absortive capacity is always delayed because firms need to adjust their knowledge. Another important aspect of this result is that a new marketing method involving significant changes in product promotion or pricing needs to be improved and changed over time because the consumers ask for constant changes to meet their needs, this result is consistent with the concept of marketing innovation proposed by OCDE (2005).

Table 5. Manufacturing Sector
Economic and Productivity performance by advertising spending strategy

	Dependent variable: $\hat{a}_{it}$				*Dependent variable*: *LaborProductivity*$_{it}$				*Dependent variable*: y_{it}			
	TFP level (1)	TFP growth (2)	TFP level (3)	TFP growth (4)	Labor Productivity level (5)	Labor Productivity growth (6)	Labor Productivity level (7)	Labor Productivity growth (8)	Gross Revenue level (9)	Gross Revenue growth (10)	Gross Revenue level (11)	Gross Revenue growth (12)
Advertising Investment$_{it-n}$	0.04*** (0.01)	-0.01 (0.01)	0.03*** (0.01)	-0.01 (0.01)	0.24*** (0.02)	-0.02 (0.02)	0.23*** (0.03)	0.02 (0.02)	0.84*** (0.03)	-0.05*** (0.01)	0.76*** (0.03)	-0.02*** (0.01)
Size	0.14*** (0.01)	0.02*** (0.01)	0.14*** (0.01)	0.07*** (0.01)	1.01*** (0.04)	0.02 (0.02)	0.97*** (0.04)	0.07*** (0.02)	3.13*** (0.05)	0.05*** (0.01)	3.10*** (0.05)	0.11*** (0.01)
FDI	0.02*** (0.01)	-0.01 (0.01)	0.02*** (0.01)	-0.02 (0.02)	0.14*** (0.05)	0.01 (0.01)	0.13*** (0.05)	-0.02 (0.02)	0.40*** (0.05)	-0.02 (0.02)	0.40*** (0.05)	-0.02 (0.02)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ISIC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	23,828	19,985	23,828	18,425	23,828	19,985	23,828	18,425	23,828	19,985	23,828	18,425

Notes: Estimates correspond to equation 6. Robust standard errors to heteroskedasticity of estimated coefficients in parentheses. *** indicates the significance at 1% confidence level. Advertising Spending is a dummy variable being 1 if firm *i* invest in advertising on year t, being the reference category non-advertising spending firms. We apply a set 24 industry, 11 time, and 4 region dummies. TFP, Labor Productivity, and Gross Revenue levels are in logs. Columns (3), (4), (7), (8), (11) and (12) the t-n represents the second lag of advertising spending status firm.

Table 5 shows that firms that invest in advertising a previous year have a higher TFP, specifically on 4%, the labor productivity on 24%, and gross revenue on 84% compared with firms that not invest in advertising. Additionally, firms that invest in advertising two delayed years have a higher TFP, specifically on 3%, the labor productivity on 23%, and gross revenue on 76% compared with firms that not invest in advertising. These results show that there is a persistent effect on this economic and productivity performance. However, it is always smaller than the effect in the same year, as is showed in Table 4.

5. Final Remarks

We use a microeconomic dataset from the supervisory institution SCVS to explore the differences between economic and productivity performance between advertising investment firms and non-advertising investment firms in the Ecuadorian manufacturing sector during the period 2007 – 2017. This paper applies three different approaches to get robust evidence about the differences between those groups of firms. First, we obtain the *Advertising Premia* for all the outcomes variables using a regression that allows controlling for size, FDI, region, industry, and year. Second, we estimate the TFP using several production functions approach. We prefer the LP estimator that controls the unobserved heterogeneity and simultaneous inputs decision problems. Finally, using the TFP of LP estimator, we measure the differences in TFP between advertising investment firms and non-advertising investment firms. Furthermore, we divide the advertising investments into many strategies that firms could apply to increase not only TFP, also gross revenue.

The results indicate that manufacturing firms that invest in advertising (continuing and entering advertising investment) have an *Advertising Premia* on economic and productivity variables; particularly, *Advertising Premia* is higher on economic outcomes. In this sense, results suggest that investments in advertising increase productivity and economic performance. Additionally, the differences in productivity between advertising investment firms and non-advertising investment firms in the manufacturing sector are around 22% permanently higher TFP.

Likewise, this research finds systematic patterns in the relationship between performance at the firm level and transitions between the invest in advertising and non-investment in advertising. In particular, this paper finds that continuing, entering, switching and exiting advertising investments firms have greater TFP than non-advertising investments firms; this paper also finds that continuing advertising investment strategy firms have higher TFP, labor productivity and gross revenue than exiting advertising investment firms, suggesting a self-selection in the exit side of the market but not in the entry side of the market, because entering advertising investment strategy firms have the same TFP, and lower labor productivity and gross revenue than exiting counterparts.

Form the side of the learning hypothesis. This study finds that after firms entering to invest in advertising, firms experience an improvement in TFP, labor productivity, and gross revenue growth, which are in favor of learning by advertising hypothesis. This evidence is clearer when we test the argument that investments in advertising could have a lag effect on economic performance, specifically on sales and productivity. These results go in line with the hypothesis suggested by other authors that mention the impact of advertising in revenue is not immediately, is an investment that obtains their premias years after the investment.

Finally, these findings have some policy implications in terms of industrial policy. First, although the intensity of advertising investment is low, those intensive firms have a higher productivity than those that do not spend in this area, this implies that if a certain amount of advertising investment is implemented, it could be considered as innovation in product or market, since the success of a new product or process on the market may depend on the quality of advertising (Mohnen & Hall, 2013) and that this investment has fiscal incentives, it may also help to improve firms innovation given its effect on product differentiation which might, in turn, improve business sales and job creation. Second, improving the quality of products is also advertising investment, many actions that may help firms to differentiate themselves from competitors and also increase TFP and gross revenue.

Even though this paper analysis the relationship of investment in advertising and various measures of productivity and economic performance in the Ecuadorian manufacturing sector, the present study has some limitations. First, those derived from the nature of the data source used since firms may not report certain investments or place them in other types of accounts. Second, this study focuses only in advertising investments; however, there is a growing current that studies complementarities, see for example Añón Higón, Gómez, & Vargas (2017), Ennen & Richter (2010). In addition, our dataset does not allow us to study complementarities since no information about R&D, human capital, patents organizational innovation is given. Finally, these results should be interpreted with caution because not major evidence in other Latin American countries is known; this is why this evidence aims to open the debate in similar Ecuadorian economies.

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Annexes

Table 1A. Sector C: Manufacturing Industries

CIIU 4.0	Subsector
C10	Manufacture of food products
C11	Manufacture of beverages
C12	Manufacture of tobacco products
C13	Manufacture of textile products
C14	Manufacture of wearing apparel
C15	Manufacture of leather and related products
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	Manufacture of paper and paper products
C18	Printing and reproduction of recorded media
C19	Manufacture of coke and refined petroleum products
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	Manufacture of rubber and plastics products
C23	Manufacture of other non-metallic mineral products
C24	Manufacture of basic metals
C25	Manufacture of fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment N.E.C.
C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	Manufacture of other transport equipment
C31	Manufacture of furniture
C32	Other manufacturing
C33	Repair and installation of machinery and equipment

Source: Superintendencia de Compañías, Valores y Seguros; EcuadorianNational Institute os Statistics.
Elaboration: The author

Table2A. Number of firms incurring in Advertising investments by two-digit ISIC

Year	*Two-Digit ISIC*																							
	10	***11***	***12***	***13***	***14***	***15***	***16***	***17***	***18***	***19***	***20***	***21***	***22***	***23***	***24***	***25***	***26***	***27***	***28***	***29***	***30***	***31***	***32***	***33***
2007	72%	82%	100%	61%	53%	70%	53%	71%	58%	33%	64%	77%	61%	65%	71%	60%	64%	72%	59%	62%	29%	59%	65%	49%
2008	67%	72%	100%	58%	58%	64%	51%	76%	52%	58%	61%	76%	56%	62%	68%	43%	50%	56%	43%	58%	37%	60%	61%	36%
2009	70%	73%	50%	66%	64%	72%	62%	67%	62%	62%	66%	76%	61%	72%	72%	57%	52%	56%	58%	75%	44%	69%	52%	40%
2010	71%	64%	100%	58%	60%	70%	55%	64%	53%	57%	65%	77%	61%	73%	62%	56%	50%	65%	49%	62%	45%	62%	57%	40%
2011	65%	58%	100%	60%	64%	66%	56%	55%	61%	65%	62%	76%	62%	69%	65%	51%	53%	67%	56%	62%	59%	63%	62%	40%
2012	59%	53%	60%	55%	57%	57%	42%	55%	48%	53%	55%	67%	50%	60%	54%	42%	52%	56%	48%	53%	34%	55%	43%	35%
2013	49%	55%	50%	51%	58%	54%	43%	46%	46%	68%	53%	64%	48%	54%	44%	42%	41%	49%	44%	47%	28%	55%	42%	35%
2014	62%	60%	75%	62%	64%	70%	45%	56%	51%	65%	58%	74%	57%	59%	57%	49%	47%	59%	43%	59%	33%	65%	43%	34%
2015	64%	66%	50%	60%	64%	66%	55%	57%	52%	62%	65%	75%	59%	63%	60%	48%	48%	63%	51%	58%	47%	54%	51%	36%
2016	65%	58%	67%	59%	60%	61%	50%	57%	49%	52%	59%	74%	55%	63%	56%	45%	39%	61%	44%	56%	44%	58%	48%	34%
2017	65%	60%	67%	59%	61%	55%	50%	60%	49%	63%	62%	79%	59%	59%	53%	47%	50%	54%	44%	60%	39%	62%	67%	31%

Source: Superintendencia de Compañías, Valores y Seguros
Elaboration: The author

Table 3A. Total number of firms by two-digit ISIC

Year	*Two-Digit ISIC*																							
	10	***11***	***12***	***13***	***14***	***15***	***16***	***17***	***18***	***19***	***20***	***21***	***22***	***23***	***24***	***25***	***26***	***27***	***28***	***29***	***30***	***31***	***32***	***33***
2007	274	44	2	98	77	30	38	45	135	6	156	52	140	84	38	89	14	29	41	37	7	63	34	113
2008	358	68	2	111	112	39	45	55	164	12	204	76	182	112	50	127	18	39	60	50	16	75	44	191
2009	447	88	2	137	115	43	52	66	178	13	221	79	203	121	57	136	23	43	64	53	16	95	44	185
2010	495	94	2	154	151	63	60	75	217	14	255	88	223	136	63	159	26	46	71	58	22	108	53	240
2011	516	88	3	146	159	68	70	82	226	17	265	92	218	138	69	168	32	52	75	64	22	111	47	257
2012	564	88	5	164	179	74	73	85	250	19	289	106	231	151	67	191	42	64	91	66	32	110	54	302
2013	450	85	4	134	144	65	69	68	222	19	229	72	177	126	54	184	49	63	103	60	25	94	50	297
2014	554	89	4	163	165	70	78	88	231	23	279	102	221	155	70	196	55	71	101	76	27	107	54	296
2015	562	90	4	157	172	70	69	84	236	21	304	106	221	160	67	193	48	65	100	77	30	105	53	309
2016	578	89	3	155	177	67	72	80	209	21	310	109	217	143	68	207	54	66	108	73	32	106	56	290
2017	503	80	3	138	153	55	62	70	171	19	281	99	194	112	59	176	48	63	90	67	28	79	49	262

Source: Superintendencia de Compañías, Valores y Seguros
Elaboration: The author

Table 4A. Advertising Spending Firms by year

	2007	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***
Advertising Spending Firms	63%	58%	64%	61%	60%	52%	48%	56%	58%	56%	56%
Non- Advertising Spending Firms	37%	42%	36%	39%	40%	48%	52%	44%	42%	44%	44%

Source: Superintendencia de Compañías, Valores y Seguros
Elaboration: The author

Table 5A. Firm's distribution by region

	Costa	***Sierra***	***Oriente***	***Insular***
Advertising Spending Firms	1,504	2,296	20	3
Non- Advertising Spending Firms	914	606	27	2
Total	2,418	2,902	47	5

Source: Superintendencia de Compañías, Valores y Seguros
Elaboration: The author

Componentes del Ecosistema de Emprendimiento de Lima que Inciden en Crecimiento y Desarrollo de *Startups*

Karen E. Weinberger Villarán[1]

Abstract: Los ecosistemas de emprendimiento impulsan la competitividad de las *startups* y estas, a su vez, contribuyen al progreso y bienestar socio-económico. Por ello, el interés en estudiar los componentes del ecosistema de emprendimiento de Lima que inciden en el crecimiento y desarrollo de *startups*. En febrero 2017, una muestra de 137 *startups* vinculadas a Innóvate Perú, respondieron un cuestionario. Posteriormente se efectuó un análisis factorial exploratorio –con método ACP– un análisis de clústeres, un ANOVA unidireccional y tablas cruzadas. Se identificaron dos componentes y tres clústeres, caracterizados por la antigüedad y el sector productivo de la *startup*. Los hallazgos sugieren que la incidencia de los componentes, depende de la fase del proceso de emprendimiento en que se encuentre la *startup*.

Palabras clave: Componentes de ecosistemas de emprendimiento; crecimiento y desarrollo de *startups*; caracterización de *startups*; Lima

Components of the Entrepreneurship Ecosystem of Lima that Affect the Growth and Development of Startups

Abstract: Entrepreneurship ecosystems boost the competitiveness of startups and these, in turn, contribute to socio-economic progress and well-being. Therefore, the interest in studying the components of the entrepreneurial ecosystem of Lima that affect the growth and development of startups. In February 2017, a sample of 137 startups linked to Innóvate Peru, answered a questionnaire. Subsequently, an exploratory factor analysis was performed –using the PCA method–, a cluster analysis, a unidirectional ANOVA and cross tables. Two components and three clusters were identified, characterized by the age and the productive sector of the startup. The findings suggest that the incidence of the components depends on the stage of the entrepreneurship process in which the startup is going through.

Keywords: Components of entrepreneurial ecosystems; growth and development of startup ecosystems; startup characterization; Lima

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Introducción

Las *startup*s han demostrado ser agentes fundamentales para el desarrollo económico y el bienestar social de una determinada localidad (Mack & Mayer, 2016), por su capacidad para innovar, romper modelos de negocio tradicionales, generar puestos de trabajo y transformar industrias (Finger & Samwer, 1998). Sin embargo, para alcanzar el éxito, este tipo de organizaciones requiere de ecosistemas de emprendimiento que faciliten su surgimiento y rápido crecimiento, especialmente en contextos cada vez más globales y competitivos, como el de países emergentes (Hernández & González, 2016; Roberts et al., 2017).

Estos ecosistemas, con características locales y regionales particulares (Mason & Brown, 2014), están conformados por diversos elementos –dominios, atributos o componentes– y un conjunto de actores, cuyas acciones y relaciones pueden influir en: i) la intención de emprender (Motoyama y Knowlton, 2016), ii) el proceso de emprendimiento (Shane & Venkataraman, 2000), iii) el tipo de emprendimiento (Blank, 2003), y iv) el crecimiento y desarrollo de *startups* (Olutuase, Brijlal, Yan, & Ologundudu, 2018)the Global Entrepreneurship Monitor (GEM.

El estudio de los ecosistemas de emprendimiento ha despertado el interés de investigadores y académicos (Auerswald et al., 2015; Clarysse, Wright, Bruneel, & Mahajan, 2014; Spigel & Harrison, 2018), por sus aportes a la competitividad de las *startups* y al crecimiento y desarrollo regional (Malecki, 2018). Sin embargo, como señalan Nicotra et al. (2018), la mayoría de los estudios se han centrado en listar los elementos o factores relevantes para el éxito de los ecosistemas de emprendimiento, basándose en la experiencia directa de los investigadores o teorías previas, mas no en estudios o verificaciones empíricas de determinadas localidades o regiones y desde la perspectiva de los emprendedores (Stam & Spigel, 2016). Además, especialmente en América Latina, la falta de data primaria es uno de los grandes problemas de la región (Lopez & Alvarez, 2018). Por ello, el interés en desarrollar un estudio empírico que permita identificar los componentes del ecosistema de emprendimiento de Lima que inciden el crecimiento y desarrollo de *startups*.

El Perú es un país emergente, con una población que supera los 32 millones de habitantes (Instituto Nacional de Estadística e Informática, 2018) y un PBI de aproximadamente US$ 225 mil millones en 2018 (Banco Central de Reserva del Perú, 2019). En los últimos diez años, los sólidos fundamentos macroeconómicos y el aumento de la

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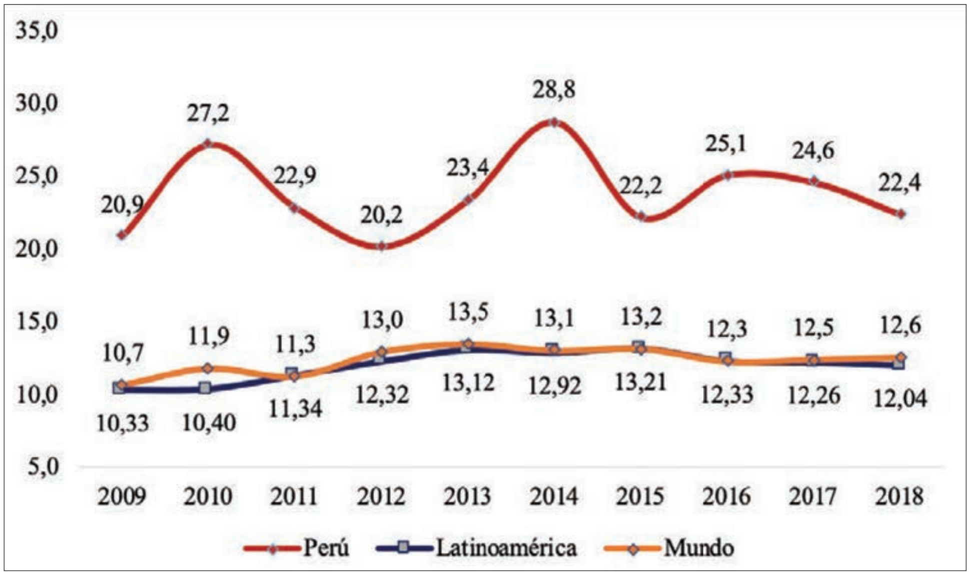
Población Económicamente Activa (PEA) de 55% en 2009 a 56.4% (aproximadamente 18 millones) (Instituto Nacional de Estadística e Informática, 2019b), le han permitido crecer a un promedio anual de 4.39 % en los últimos diez años y disminuir el índice de pobreza de 33.5% en 2009 a 20.5% en 2018 (Instituto Nacional de Estadística e Informática, 2019a).

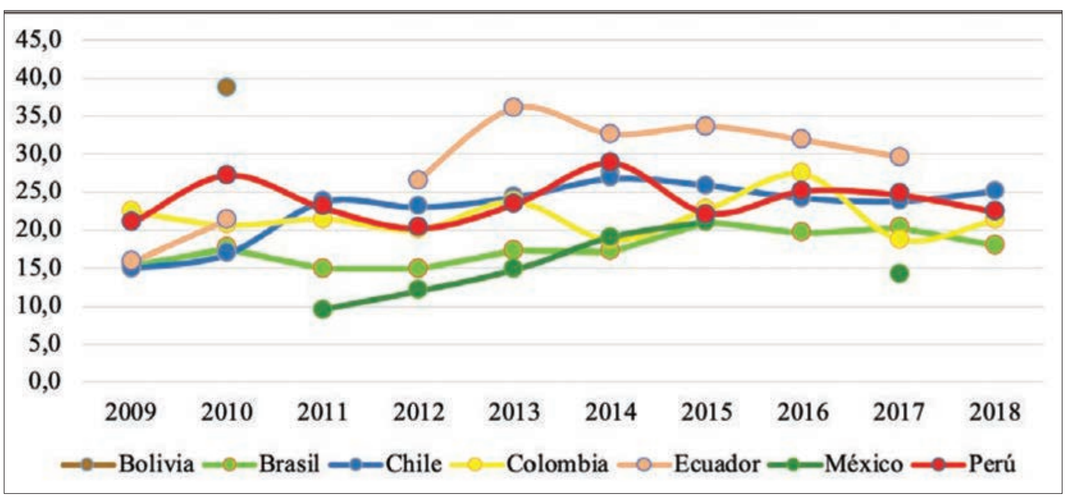
Por otro lado, como señalan los estudios del *Global Entrepreneurship Monitor* (*GEM*), en Perú existe una cultura que promueve, estimula y valora el emprendimiento, lo que se refleja en tasas de emprendimiento en etapas tempranas[1] –TEA por sus siglas en inglés– superiores al promedio global (Bosma & Kelley, 2019) y entre las tres más altas de la región Latinoamericana (Serida, Alzamora, Guerrero, Borda, & Morales, 2016), como se observa en las Figuras 1 y 2. Además, en 2018, ocupó el quinto lugar entre un total de 48 países que participaron en la investigación (Bosma & Kelley, 2019).

Figura 1. Evolución anual de la actividad emprendedora en etapa temprana (TEA), Perú y mundo: 2009-2018 (%)



Fuente: Global Entrepreneurship Monitor (Bosma & Kelley, 2019)
Elaboración propia

Figura 2. Evolución anual de la actividad emprendedora en etapa temprana (TEA), en países de la región con mayores TEA: 2009-2018 (%)



Fuente: Global Entrepreneurship Monitor (Bosma & Kelley, 2019)
Elaboración propia

[1] Índice de Actividad Emprendedora en Etapa Temprana (TEA por sus siglas en inglés). Se refiere al porcentaje de la población, entre 18 y 64 años de edad, que se encuentra activamente en la puesta en marcha de un negocio del cual será dueño o copropietario, o que posee y gestiona un negocio en marcha y que ha pagado sueldos, salarios o cualquier otra retribución a los propietarios por un periodo no mayor a 42 meses (Serida et al., 2018).

Sin embargo, estudios sobre el emprendimiento en América Latina señalan que, a pesar de las condiciones macroeconómicas favorables en el Perú (Kantis, Federico, & Ibarra García, 2017, 2018), los avances en el desarrollo de políticas públicas en favor del emprendimiento (OCDE, 2016) y las altas tasas de emprendimiento en etapa temprana (Serida et al., 2016; Serida, Guerrero, Alzamora, Borda, & Morales, 2017), los emprendimientos en el país siguen siendo poco innovadores, tienen bajos niveles de desarrollo tecnológico, muy pocos logran escalar a nivel regional y la mayoría está centralizada en Lima, la capital política. Esta metrópoli concentra el 36.4% del PBI del país[2], el 29.2% de la Población Económicamente Activa (PEA)[3] (Instituto Nacional de Estadística e Informática, 2019b) y alcanza el 13.1% del índice de pobreza[4] (Instituto Nacional de Estadística e Informática, 2019a). Además, concentra el 77% de las *startups* del país (OECD, 2016b), el 61.7% de los proyectos y el 66.7% de los fondos otorgados por Innóvate Perú, la plataforma de innovación del país (Ministerio de la Producción, 2019). A pesar de ello, la supervivencia, así como el crecimiento y desarrollo de *startups* en Lima, sigue siendo un reto (Hernández & González, 2016).

Por lo tanto, dada la importancia de los ecosistemas de emprendimiento para la competitividad de las *startups* y el bajo nivel de innovación, desarrollo tecnológico y escalabilidad de las *startups* en Lima, surge el interés por conocer los componentes del ecosistema de emprendimiento de Lima que inciden en el crecimiento y desarrollo de *startups*, y así contribuir al desarrollo de un marco teórico sobre ecosistemas de emprendimiento.

Para llevar a cabo el estudio, a partir de un cuestionario, se realizó un análisis factorial exploratorio utilizando el método de análisis de componentes principales, un análisis de clústeres, un ANOVA unidireccional y tablas cruzadas para caracterizar a las *startups* de cada uno de los clústeres identificados.

Los resultados pretenden aportar al escaso número de estudios empíricos sobre componentes de ecosistemas de emprendimiento (Brown, Mawson, & Mason, 2017; Mason & Brown, 2014), de países emergentes como Perú (Kantis et al., 2018). Se espera que los resultados sean tomados en consideración por los formuladores de programas e instrumentos en favor del desarrollo de ecosistemas de emprendimiento para *startups*.

A continuación, se hace una revisión de la literatura sobre *startups* y ecosistemas de emprendimiento, luego se presenta la metodología empleada para la investigación, los resultados obtenidos y la discusión de los mismos. Finalmente se presentan las conclusiones, recomendaciones e implicancias para formuladores y gestores de políticas públicas.

Revisión de literatura

El fenómeno del emprendimiento ha pasado de estudiar al emprendedor y su proceso para la creación de nuevas empresas, al estudio de los ecosistemas de emprendimiento que impulsan el surgimiento y desarrollo de un nuevo tipo de organización llamada *startup*. Sin embargo, si bien en todas las regiones se desarrolla alguna actividad emprendedora y muchas tienen ecosistemas de emprendimiento, no todos los ecosistemas promueven el surgimiento de *startups* ni contribuyen con servicios para aumentar su competitividad (Roundy, Brockman, & Bradshaw, 2017), por ello el interés en estudiarlos.

El fenómeno de las *startups* ha atraído la atención de académicos e investigadores, medios de comunicación, especialistas en innovación, inversionistas y formuladores de políticas públicas, por la relevancia de este tipo de organizaciones en el progreso económico y bienestar de la sociedad (OCDE, 2017). Aunque no se ha llegado a un consenso sobre la definición de *startup*, Skala (2019) sostiene que todas las definiciones tienen algunas de las siguientes cuatro características: i) se trata de organizaciones jóvenes con recursos financieros escasos; ii) que ofrecen soluciones innovadoras, de manera innovadora y con modelos de negocio innovadores; iii) que, por ser organizaciones ambiciosas, crecen rápidamente; y iv) suelen ser empresas tecnológicas. Además, son consideradas organizaciones de innovación abierta muy poderosas (Spender, Corvello, Grimaldi, & Rippa, 2017) que cumplen un rol importante en los procesos de innovación.

Por otro lado, el término "sistema de emprendimiento" fue introducido por Spilling (1996), quien sostuvo que el desempeño empresarial estaría afectado por los roles e interacciones entre los actores, así como por aspectos socioculturales, los ciclos económicos, la estructura de las empresas, el análisis de oportunidades, el tipo de actividades empresariales y las características de las relaciones entre los emprendedores. En estos sistemas se darían procesos de intercambio de información, conocimientos y servicios, en condiciones de colaboración y competencia (Spilling, 1996).

En 2006, Cohen introduce el concepto de "ecosistema de emprendimiento", haciendo referencia a un grupo interconectado de actores –universidades, gobierno, profesionales, servicios de apoyo, financiamiento, talento humano– en una comunidad geográfica local, cuyos vínculos formales e informales, infraestructura física y cultura, contribuyen a la sostenibilidad del ecosistema. Es decir, se trata de un conjunto de componentes –diferentes e interdependientes– que interactúan para apoyar la creación de nuevas empresas a través de *startups*.

Malecki (2018), en su afán por aclarar algunos conceptos, sostiene que los ecosistemas de emprendimiento, a diferencia de los ecosistemas empresariales, clústeres, distritos industriales y sistemas de innovación, centran su estudio en las condiciones para el surgimiento de nuevas iniciativas empresariales y la supervivencia y crecimiento de sus *startups*. Por lo tanto, el éxito de un ecosistema de emprendimiento debería estar definido por su capacidad para apoyar el entorno regional y el sano crecimiento de las *startups*, y no solo por las altas tasas de emprendimiento.

[2] Equivale a aproximadamente US82 mil millones (Banco Central de Reserva del Perú, 2019).
[3] Aproximadamente 5 millones están en Lima.
[4] De las 9 millones 320 mil personas, que se estima viven en Lima, aproximadamente 1 millón 220 mil se encuentra en situación de pobreza.

Isenberg, uno de los primeros investigadores en proponer un marco de referencia para el estudio de los ecosistemas de emprendimiento (Isenberg, 2010), agrupó decenas de elementos claves de los ecosistemas en trece componentes que consideraba esenciales para los ecosistemas de emprendimiento. Posteriormente, el mismo autor propone seis categorías o dominios. Estos son: i) una cultura que promueva el emprendimiento (I1), ii) la disponibilidad de recursos financieros apropiados para *startups* (I2), iii) un mercado de clientes suficiente (I3), iv) capital humano de calidad (I4), v) facilidades de infraestructura (I5), y vi) políticas públicas que favorezcan el surgimiento de nuevas iniciativas empresariales (I6) (Isenberg, 2011).

Por otro lado, el *Regional Entrepreneurship Acceleration Program* del *Massachusetts Institute of Technology* (*MIT REAP* por sus siglas en inglés) propone un marco de referencia para el estudio de los ecosistemas de emprendimiento "impulsados por la innovación", basado en tres pilares fundamentales: i) la *capacidad para innovar*, es decir la habilidad para desarrollar nuevas tecnologías; ii) la *capacidad para emprender*, relacionada con la habilidad para lograr el rápido crecimiento de la *startup*; y iii) el *apoyo de instituciones del clúster económico* presente en una determinada región (Murray & Stern, 2015). Este marco de referencia que busca responder a la pregunta: ¿cómo puede una región aprovechar el espíritu empresarial impulsado por la innovación para el progreso económico y social?, identifica seis elementos que contribuyen a promover el emprendimiento y la innovación regional, como se pueden apreciar en la Tabla 1.

Tabla 1. Elementos y actividades del ecosistema de emprendimiento e innovación

Actividades para promover la capacidad de innovar	**Elementos del ecosistema**	**Actividades para promover la capacidad de emprender**
Celebraciones por inventos o innovaciones Premios a la innovación Carreras de investigadores	(MS1) Cultura y comunidad	Comportamiento frente al emprendimiento y al fracaso Reconocimiento a la actividad emprendedora, premios, concursos
Pool de innovadores Formación en tecnología y ciencia	(MS2) Capital humano	*Pool* de emprendedores Formación en emprendimiento
Acceso a fondos para investigación Programas de gobierno	(MS3) Financiamiento	Acceso a capital emprendedor, gobierno, inversionistas, concursos
Laboratorios, capacitaciones, bases de datos	(MS4) Infraestructura	Espacios, internet, logística, entrenamiento
Políticas para transferencia tecnológica, propiedad intelectual, registro de patentes	(MS5) Políticas públicas	Políticas y leyes para creación de empresas Libre competencia
Naturaleza de las empresas que están en la región	(MS6) Demanda	Nuevos productos o servicios por parte de: gobierno, corporaciones, empresas, consumidores locales

Fuente: Instituto de Tecnología de Massachusetts, Programa Regional de Aceleración de Emprendimiento, *cohort* 4. (*MIT-REAP* por sus siglas en inglés)
Elaboración propia

Murray y Stern (2015), integrantes del equipo de profesores e investigadores del *MIT REAP*, señalan que para el éxito de las *startups* se requiere, además de emprendedores con capacidad para innovar y emprender, el apoyo y soporte de otros actores, como la academia, las corporaciones, el Estado, los inversionistas y otros emprendedores, cuya experiencia, conocimiento, capacidad de inversión y redes de contacto, aportan al emprendedor e impulsan el emprendimiento basado en la innovación.

Kantis, Federico, Ibarra García y Menéndez (2015) –expertos en emprendimiento latinoamericano– señalan que los ecosistemas para emprendimientos dinámicos están compuestos por diez dimensiones o componentes, asociados a tres factores o ejes conceptuales que promueven o inhiben el desarrollo de emprendimientos dinámicos, como se muestran en la Tabla 2.

Tabla 2. Ejes conceptuales y dimensiones de los ecosistemas de emprendimiento dinámico

Ejes conceptuales	Dimensiones o componentes
Factores que estimulan una masa crítica de emprendedores	(K1) Capital humano emprendedor (K2) Sistema educativo (K3) Cultura local que promueva el emprendimiento innovador (K4) Condiciones sociales
Factores que afectan la existencia de oportunidades de negocios	(K5) Condiciones de la demanda (K6) Estructura empresarial (K7) Plataforma de ciencia y tecnología que permite transformar los conocimientos en innovación
Factores que promueven o inhiben el desarrollo de emprendimientos dinámicos	(K8) Ambiente apropiado que facilite las relaciones y redes entre los diversos actores clave como empresarios e instituciones que faciliten el acceso a recursos (capital social) (K9) Financiamiento para las diversas etapas del proceso de emprender (K10) Políticas y regulaciones que fomentan o inhiben actividad emprendedora

Fuente: Kantis, Federico, Ibarra García, et al. (2015)
Elaboración propia

Por su parte, Spigel (2015) hace una revisión de la literatura para identificar los elementos que, por su relevancia para el surgimiento, crecimiento y desarrollo de empresas innovadoras, han sido estudiados entre los años 1989 y 2014. Spigel propone clasificar estos elementos en diez atributos, que luego agrupa en tres categorías i) atributos culturales, ii) atributos sociales, y iii) atributos materiales (ver Tabla 3).

Tabla 3. Atributos de los ecosistemas de emprendimiento

Tipo de atributo	Atributo	Descripción
Cultural	(Sc1) Cultura de apoyo al emprendimiento (Sc2) Historia de emprendedores	Normas culturales que promueven y apoyan el emprendimiento Historias de emprendimientos locales exitosos
Social	(Ss1) Redes sociales (Ss2) Capital emprendedor (Ss3) Mentores y modelos a seguir (Ss4) Trabajadores talentosos	Redes sociales que conectan actores y facilitan el uso de los recursos del ecosistema Disponibilidad de fondos de capital emprendedor (familia, amigos, inversores ángeles, capital de riesgo) Exitosos emprendedores locales que son mentores de nuevos emprendedores Disponibilidad de trabajadores talentosos, deseosos de trabajar en una *startup*
Material	(Sm1) Universidades (Sm2) Servicios de apoyo e infraestructura (Sm3) Políticas y gobierno (Sm4) Mercados abiertos	Instituciones académicas que forman emprendedores, crean nuevos conocimientos y desarrollan talento para las *startups* Incubadoras, aceleradoras, estudios contables y de abogados, oficinas de patentes y transferencia tecnológica. Disponibilidad de oficinas, servicios logísticos, informáticos y de telecomunicaciones Programas del gobierno o regulaciones que apoyan el emprendimiento a través de financiamiento directo o quitando las barreras a la creación de empresas Suficientes oportunidades locales para iniciar emprendimientos y que no hayan impedimentos para acceder mercados globales

Fuente: Spigel (2015)

Los *atributos culturales* se basan en las normas o creencias de una determinada región o localidad, con respecto a la actividad de emprender; los *atributos sociales* se refieren a las relaciones que se dan entre los múltiples actores de los ecosistemas, con el fin de conseguir los recursos necesarios para cada etapa del proceso de emprender; mientras que los *atributos materiales* se refieren a la existencia de infraestructura o recursos tangibles como son: las universidades, las incubadoras de empresas, los centros de investigación, los estudios de abogados, los servicios contables y las políticas públicas en favor de las *startups*, ya sea para financiar emprendimientos o remover barreras a la creación de nuevas iniciativas empresariales. Spigel y Harrison (2018) sostienen que el tipo de recursos disponibles en un ecosistema (atributos materiales) y la habilidad para que estos recursos fluyan a través de las redes de contacto social (atributos sociales), contribuirán al buen funcionamiento y desarrollo de ecosistemas fuertes.

Otros autores (Ács, Autio, y Szerb, 2014; Welter, Baker, Audretsch, y Gartner, 2017) afirman que sin una cultura de apoyo al emprendimiento, ni emprendedores con la capacidad para aprovechar las oportunidades generadas en determinadas regiones o localidades, será difícil desarrollar ecosistemas de emprendimiento favorables para el crecimiento y desarrollo de *startups*. Sin embargo, una cultura emprendedora no asegura el surgimiento, crecimiento y desarrollo de *startups,* pues este tipo de emprendimientos requieren de ecosistemas que los estimulen a innovar y conseguir los recursos necesarios para ser competitivos, crecer y desarrollarse a nivel global (Murray & Stern, 2015).

La literatura muestra que, en la última década, el estudio sobre ecosistemas de emprendimiento se ha centrado en identificar los aspectos relevantes para su éxito y los efectos en la actividad emprendedora (Nicotra et al., 2018), pues los elementos de un ecosistema "nutren" a una startup (Tripathi, Seppänen, Boominathan, Oivo, & Liukkunen, 2019). Sin embargo, dada la variedad aspectos identificados, investigadores y académicos han tratando de categorizarlos en elementos (Aulet, 2008; Fetters, Greene, & Rice, 2010; Isenberg, 2010; Tripathi, Oivo, Liukkunen, & Markkula, 2019), dimensiones (Gnyawali & Fogel, 1994), componentes (Isenberg, 2011; Mack & Mayer, 2016; Neck, Mayer, Cohen, & Corbett, 2004; Qian, 2018), factores (Kantis, Federico, & Ibarra García, 2015; Neck et al., 2004; Spigel, 2015; Stam & Spigel, 2016; Vogel, 2013), actores (Alvedalen & Boschma, 2017; Cohen, 2006; Isenberg, 2011; Isenberg & Onyemah, 2016; Mason & Brown, 2014; Neck et al., 2004; Roberts et al., 2017; Stam & Spigel, 2016; Vogel, 2013), niveles (Theodoraki & Messeghem, 2017), entre otros, sin llegar a un consenso que permita definir un marco teórico para el estudio de los ecosistemas de emprendimiento. Además, mientras algunos autores se centran en la importancia de crear ecosistemas de emprendimiento para fomentar el surgimiento de nuevas iniciativas empresariales; otros enfatizan en el rol que los actores de estos ecosistemas tienen para impulsar la competitividad de las startups (Auerswald et al., 2015; Clarysse et al., 2014; Spigel & Harrison, 2018).

Frente a esta falta de consenso y dado que el objetivo del estudio es identificar los componentes del ecosistema de emprendimiento que inciden en el crecimiento y desarrollo de las startups, se optó por la propuesta de Spigel, por ser la que mejor integra estos componentes. Sin embargo, en la Tabla 4, se presentan y comparan las propuestas de Isenberg, Spigel, MIT REAP y Kantis et al., para mostrar que estos también estudian los componentes culturales, sociales y materiales, aunque las dos últimas lo hacen para responder a otra pregunta: ¿cómo puede una región aprovechar el espíritu empresarial impulsado por la innovación para el progreso económico y social? Esta es una pregunta vinculada al estudio de los clústeres, la estrategia y la ventaja competitiva de cada región, más que al estudio de los componentes de un ecosistema de emprendimiento.

Frente a esta falta de consenso, y dadas las similitudes entre los cuatro modelos planteados, se optó por integrarlos en función a los tres tipos de atributos más comunes en la literatura (ver Tabla 4).

Tabla 4. Comparación de los elementos de ecosistemas propuestos por Isenberg (I), Murray & Stern (MS), Kantis et al. (K) y Spigel (S)

Atributos sociales	Atributos materiales
(I2) Disponibilidad de recursos financieros apropiados para *startups*	(I3) Mercado de clientes suficiente
(I4) Capital humano de calidad	(I5) Facilidades de infraestructura
	(I6) Políticas públicas que favorezcan el surgimiento de nuevas iniciativas empresariales
(K4) Condiciones sociales	(K5) Condiciones de la demanda
(K8) Ambiente apropiado que facilite las relaciones y redes entre actores y acceso a recursos	(K6) Estructura empresarial
(K9) Financiamiento para las diversas etapas del proceso de emprender	(K7) Plataforma de ciencia y tecnología que permiten transformar los conocimientos en innovación
	(K10) Políticas y regulaciones que fomentan o inhiben actividad emprendedora
(Ss1) Redes sociales	(Sm1) Universidades, conocimiento y entrenamiento a emprendedores
(Ss2) Disponibilidad de capital para inversión	(Sm2) Servicios de apoyo e infraestructura
(Ss3) Mentores y modelos a seguir	(Sm3) Políticas y gobierno
(Ss4) Trabajadores talentosos	(Sm4) Mercados abiertos
(MS2) El capital humano	(MS4) La infraestructura
(MS3) El financiamiento	(MS5) Las políticas públicas
	(MS6) La demanda
Atributos culturales	
(I1) Cultura que promueva el emprendimiento	(Sc1) Cultura de apoyo al emprendimiento
	(Sc2) Historia de emprendedores
(K1) Capital humano emprendedor	(MS1) La cultura y la comunidad
(K2) Sistema educativo	
(K3) Cultura local que promueva el emprendimiento innovador	

Es importante señalar que la investigación se enfoca en el estudio de las variables que contribuyen con el *crecimiento y desarrollo de startups*, mas no en las variables que impulsan el surgimiento de nuevas iniciativas empresariales, pues estudios previos del *GEM* (Serida et al., 2016) señalan que en Perú existe una una fuerte cultura promotora del emprendimiento, por lo que el atributo cultural no fue analizado.

A continuación, se presenta la metodología empleada para identificar los componentes que, desde la perspectiva de los emprendedores fundadores de *startups*, han tenido mayor influencia en el crecimiento y desarrollo de sus *startups*.

Metodología

Dado que el estudio de los ecosistemas de emprendimiento es un fenómeno complejo (Roundy, Bradshaw, & Brockman, 2018) que hasta el momento no ha sido suficientemente expuesto a la comunidad de investigadores, especialmente en países latinoamericanos (Lopez & Alvarez, 2018), se decidió explorar y comprender el fenómeno a través de un estudio de caso (Yin, 2013). Se eligió el caso de las *startups* de Innóvate Perú. Innóvate Perú es el Programa Nacional de Innovación para la Competitividad y Productividad, que busca incrementar la innovación productiva, impulsar el emprendimiento innovador y fomentar la absorción y adaptación de tecnologías para las empresas (Ministerio de la Producción, 2014). Se eligió este caso porque Innóvate Perú es la plataforma del Estado que, desde 2014, fomenta y financia la innovación en el Perú, tiene mayor cercanía con las *startups* –indistintamente del tamaño o sector al que pertenezcan–, responde a las necesidades de ellas en sus distintas fases de desarrollo y fortalece a los actores del ecosistema de emprendimiento para startups.

En el marco del *MIT REAP*, un programa de dos años que busca mejorar los ecosistemas regionales de emprendimiento basados en innovación, el equipo de investigación del *MIT REAP Lima-cohort* 4[5] desarrolló un cuestionario en base a la revisión de la literatura y a estudios exploratorios previos del ecosistema de emprendimiento de Lima (Hernández & González, 2016; Kantis, Federico, Ibarra García, et al., 2015), con el fin de conocer cómo se venía desarrollando el ecosistema de emprendimiento peruano y qué oportunidades de mejora existían. Dicho instrumento de medición fue aplicado en una encuesta piloto a 25 emprendedores de alto impacto[6] registrados en la base de datos de Innóvate Perú, y validado cualitativamente por 12 expertos en ecosistemas de emprendimiento e innovación[7]. Tratándose de un estudio exploratorio, cuya escala de medida no había sido validada anteriormente, se realizó un análisis de convergencia para corroborar la validez del instrumento.

El cuestionario fue distribuido virtualmente en febrero de 2017 a la base de datos de emprendedores que alguna vez habían postulado a los fondos para la innovación de Innóvate Perú, pues es la que mayor número de *startups* congrega dada su misión institucional. Se obtuvieron 296 respuestas, de las cuales 137 fueron consideradas válidas para los propósitos de nuestro estudio por las siguientes razones: i) quien respondió la encuesta había fundado y se encontraba gestionando el emprendimiento, ii) el encuestado consideraba que su emprendimiento era innovador y tenía un componente tecnológico, iii) conocía los fondos para la innovación y el emprendimiento de Innóvate Perú, y iv) respondió a la pregunta: "¿qué acciones han influido en el crecimiento y desarrollo de su *startup*?"

Para medir la influencia de cada una de las 12 variables, se empleó la escala de Likert 1-7, siendo 1 "Nada influyente" y 7 "Totalmente influyente". Se calculó la media (M) como tendencia central y la desviación estándar (DS) como medida de dispersión o de variabilidad, para cada una de las variables planteadas en el cuestionario.

Para comprobar si el tamaño de la muestra era suficiente, el método elegido era el correcto y si el instrumento para el recojo de información soportaba las pruebas de confiabilidad y validez, se utilizaron el índice Kayser-Meyer-Olkin (KMO), la prueba de esfericidad de Barlett, y se estimaron el Alfa de Cronbach, la Varianza Extraída Promedio (*AVE* por sus siglas en inglés).

Posteriormente, se realizó un Análisis de Componentes Principales (ACP) para determinar a qué componentes corresponden cada una de las variables utilizadas en el estudio, luego un análisis de clústeres jerárquicos con el método de Ward en base a los componentes identificados, y un análisis ANOVA unidireccional para realizar una diferenciación de las medias entre las agrupaciones obtenidas por el análisis de clústeres. Finalmente se realizaron dos tablas cruzadas, que relacionan a la variable de clústeres con cada una de las siguientes variables: "antigüedad de la empresa" y "sector productivo".

A continuación, se presentan los resultados del estudio.

Resultados

Estadísticos descriptivos
Como se puede observar en la Tabla 5, las dos variables más valoradas por los emprendedores son: la existencia de un mercado atractivo (M=5.16) y el acceso a tecnología (M=4.73), siendo las únicas dos variables con una media superior a 4.

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[5] En esta cuarta promoción (2016 – 2018) participaron seis ciudades: Dubai, Islandia, Laos, Lima, Madrid y Nova Scotia. Cada ciudad estuvo representada por una delegación de funcionarios de: el gobierno, la academia, los emprendedores, los inversionistas y las grandes empresas. Los representantes del Perú fueron: Gonzalo Villarán Córdova (inicialmente representante de UTEC Ventures y posteriormente del Ministerio de la Producción) y Gonzalo Villarán Elías (Innóvate Perú), ambos en representación del Estado; Luis Terrones Morote y Desiree Alayza (COFIDE) y Gonzalo Begazo (Inversionista) en representación del financiamiento; Giancarlo Seco (ISEND) en representación de los emprendedores; Alessandra Corrochano (INTERCORP), Martín Ferraro (Grupo Hochschild) y Miguel Paredes (Grupo Breca) en representación de las corporaciones; José Deustua (UTEC Ventures) y Karen Weinberger (Universidad del Pacífico), ambos en representación de la academia.
[6] Innóvate Perú considera como emprendedor de alto impacto a aquel que emprendimiento innovador, que crece rápidamente y genera altos ingresos pues cubre una necesidad o aprovecha una oportunidad de mercado importante (Ministerio de la Producción, 2015).
[7] Diez en el Perú y dos en el extranjero.

Tabla 5. Estadísticos descriptivos de las variables valoradas por emprendedores

Código de variable	Dimensiones	n	Min	Max	Media	DS
V1	La existencia de fondos concursables	137	1	7	3.93	2.13
V2	La existencia de un mercado atractivo	137	1	7	5.16	1.66
V3	La existencia de aceleradoras	137	1	7	2.69	1.77
V4	La existencia de incubadoras	137	1	7	2.68	1.81
V5	La existencia de inversionistas de alto riesgo	137	1	7	2.88	1.91
V6	Visitas a otros ecosistemas de emprendimiento internacionales	137	1	7	3.45	2.04
V7	El apoyo por parte de otros emprendedores	137	1	7	3.75	2.01
V8	El apoyo por parte de mentores	137	1	7	3.36	2.06
V9	El acceso a laboratorios y centros de investigación	137	1	7	3.50	2.13
V10	El acceso a universidades y especialistas	137	1	7	3.92	2.07
V11	El acceso a *coworking* gratuito	137	1	7	2.98	2.10
V12	El acceso a la tecnología	137	1	7	4.73	1.95

Fuente: encuesta aplicada entre el 14 y 21 de febrero de 2017.

Por el contrario, las cuatro variables con valoraciones promedio inferiores a 3 son: la existencia de incubadoras (M=2.68), la existencia de aceleradoras (M=2.69), la existencia de inversionistas de alto riesgo (M=2.88) y el acceso a *coworking* gratuito (M=2.98).

Análisis de Componentes Principales

Al emplear el método de Análisis de Componentes Principales (ACP), se encontró que el índice Kayser-Meyer-Olkin (KMO) equivale a 89.6%, lo que indica que el tamaño muestral es adecuado para el análisis. Además, la prueba de esfericidad de Barlett (aprox. Chi-cuadrado = 1029.35; g.l.=66; valor-p = .000) señala que la matriz de correlaciones no es una matriz identidad, por lo que el método elegido es el correcto.

Como se muestra en la Tabla 6, se identificaron dos componentes, cuyos coeficientes Alfa de Cronbach fueron 0.91 y 0.83 superando el valor aceptado de 0.70 (Nunnally, 1994), lo que muestra el alto grado de confiabilidad que presenta cada componente. En conjunto, ambos componentes brindan un porcentaje de varianza acumulado de 65.09% que supera el valor de 60% de la varianza total señalado como satisfactoria en ciencias sociales por Hair Jr, Anderson, Tatham, & Black, (1999, p. 93).

Tabla 6. Matriz de Análisis Componentes Principales

Código de variable	Variable	Componente I	Componente II
V3	La existencia de aceleradoras	**.895**	.129
V4	La existencia de incubadoras	**.892**	.054
V5	La existencia de inversionistas de alto riesgo	**.812**	.241
V11	El acceso gratuito a *coworking*	**.764**	.335
V8	El apoyo por parte de mentores	**.634**	.494
V6	Visitas a otros ecosistemas de emprendimiento internacionales	**.627**	.436
V7	El apoyo por parte de otros emprendedores	**.548**	.502
V1	La existencia de fondos concursables	**.515**	.328
V12	El acceso a la tecnología	.155	**.838**
V10	El acceso a universidades y especialistas	.334	**.766**
V9	El acceso a laboratorios y centros de investigación	.433	**.717**
V2	La existencia de un mercado atractivo	.063	**.702**

Tal como se observa en la Tabla 6, las variables que conforman el Componente I se asocian con los atributos sociales, en tanto que las variables que conforman el Componente II pueden denominarse como atributos materiales. Por ello, en adelante, dichos componentes se denotan como “Componente social” y “Componente material”, respectivamente.

Análisis de clústeres por el método de Ward
Posteriormente, se realizó un análisis de clústeres jerárquico con el método de Ward en base a los dos componentes hallados. Los resultados muestran tres clústeres: el clúster 1 (C1) está compuesto por 55 *startups*, y los clústeres 2 (C2) y 3 (C3), por 41 *startups* cada uno.

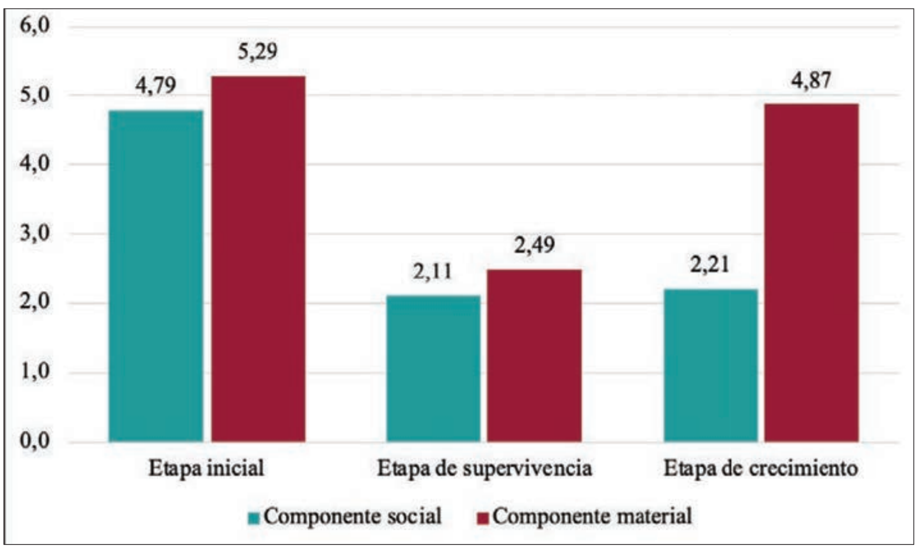
Se tomó la decisión de categorizar a los clústeres en función a la etapa del proceso de emprendimiento pues, cada fase en el desarrollo de una *startup*, tiene distintas necesidades (OCDE, 2016; Spigel & Harrison, 2018) y, por lo tanto, se asume que requerirá distintos componentes para su crecimiento y desarrollo. Así, el primer clúster se denomina "*startups en etapas iniciales*" (CI); el segundo, "*startups en etapa de supervivencia*" (CS); y el tercero, "*startups en etapa de crecimiento*" (CC).

Tabla 7. Caracterización de los clústeres en función a medias de los componentes

Denominación de clúster	Número de casos	Componente I (Medias)	Componente II (Medias)
C1: *Startups* en etapas iniciales (CI)	55	4.79 / 7	5.29 / 7
C2: *Startups* en etapa de supervivencia (CS)	41	2.11 / 7	2.49 / 7
C3: *Startups* en etapa de crecimiento (CC)	41	2.21 / 7	4.87 / 7

Se cruzaron los dos componentes obtenidos con los tres clústeres (ver Tabla 7). Considerando que el máximo puntaje que podía recibir cada variable del cuestionario fue 7 puntos, se observa que el CI puntúa positivamente en ambos componentes, el CS puntúa negativamente en ambos componentes, mientras que el CC puntúa positivamente en el componente material y negativamente en el social, lo que se aprecia con mayor claridad en la Figura 3.

Figura 3. Medias de los clústeres según componentes



Para realizar una diferenciación de medias entre las tres agrupaciones obtenidas por el análisis de clústeres, se realizó un análisis ANOVA unidireccional, el que cumplió con los supuestos de homogeneidad de varianzas. Se encontró que para el Componente social existe una diferenciación de medias entre las tres agrupaciones ($F = 161.184$; $p < 0.01$), así como también para el Componente material ($F = 95.586$; $p < 0.01$).

Al realizar el análisis post-hoc de Tukey, como se observa en Tabla 8, los clústeres de "*startups en etapa de supervivencia*" (M=2.11) y "*startups en etapa de crecimiento*" (M=2.21) no poseen una diferenciación significativa de medias para el componente I, siendo el clúster de "*startups en etapa inicial*" el que mayor puntúa en este componente (M=4.79). Sin embargo, en el caso del componente II, los clústeres de "*startups en etapa inicial*" (M=5.29) y "*startups en etapa de crecimiento*" (M=4.87) no poseen diferenciación significativa de medias y puntúan más que el clúster de "*startups en etapa de supervivencia*" (M=2,49).

Tablas cruzadas
Se desarrollaron tablas cruzadas con el fin de analizar los perfiles derivados de los componentes identificados y caracterizar a las *startups* en función de la "antigüedad de la empresa" (chi-cuadrado = 19.125; g.l. = 8; $p < 0.05$) y el "sector productivo" (chi-cuadrado = 20.533; g.l. = 12; $p < 0.10$) al que pertenecen.

a) *Antigüedad de la empresa*

En la Tabla 8 se observa que, en el CI, la mayoría de las *startups* (30 de un total de 55) tienen tres o menos años de antigüedad, es por ello que se decidió denominarlo "*startups* en etapa inicial" (SEI). En el CC, la mayoría de las *startups* (24 de un total de 41) tiene más de seis años de antigüedad, por lo cual se le denominó "*startups* en etapa de crecimiento" (SEC). Finalmente, al CS se le denominó el "*startups* en etapa de supervivencia" (SES) por ser la etapa intermedia del proceso de emprender de toda *startup.*

Como se observa en la Tabla 8, el 74.5% (41 de 55) de las s*tartups* del CI tienen cinco o menos años de antigüedad. Para el caso de las *startups en etapa de supervivencia*, no se visualiza un patrón con respecto a la antigüedad de las mismas. De las 41 *startups* en este clúster, 14.6% (6) tienen menos de un año; 29.3% (12) tienen entre uno y tres años, 12.2% (5) tienen entre tres y cinco años, 29.3% (12) entre seis y diez años, y 14.6% (6) tiene más de diez años. Del clúster de "*startups en etapa de crecimiento*", el 58.5% (24 de un total de 41) tienen seis o más años de antigüedad.

Tabla 8. Tabla cruzada de la Antigüedad de la empresa y Clústeres

Tabla cruzada "antigüedad de empresa" * Clústeres					
Número de años		***Startups* agrupadas por clústeres**			**Total de empresas por "antigüedad"**
		"*Startups* en etapa inicial" CI	**"*Startups* en etapa de supervivencia" CS**	**"*Startups* en etapa de crecimiento" CC**	
Menos de uno (21)	Recuento	12	6	3	21
	% dentro de Antigüedad de empresa	57.1%	28.6%	14.3%	100.0%
	% dentro de Clústeres	21.8%	14.6%	7.3%	15.3%
	% del total	8.8%	4.4%	2.2%	15.3%
Entre uno y tres (35)	Recuento	18	12	5	35
	% dentro de Antigüedad de empresa	51.4%	34.3%	14.3%	100.0%
	% dentro de Clústeres	32.7%	29.3%	12.2%	25.5%
	% del total	13.1%	8.8%	3.6%	25.5%
Entre tres y cinco (25)	Recuento	11	5	9	25
	% dentro de Antigüedad de empresa	44.0%	20.0%	36.0%	100.0%
	% dentro de Clústeres	20.0%	12.2%	22.0%	18.2%
	% del total	8.0%	3.6%	6.6%	18.2%
Entre seis y diez (34)	Recuento	5	12	17	34
	% dentro de Antigüedad de empresa	14.7%	35.3%	50.0%	100.0%
	% dentro de Clústeres	9.1%	29.3%	41.5%	24.8%
	% del total	3.6%	8.8%	12.4%	24.8%
Más de diez (22)	Recuento	9	6	7	22
	% dentro de Antigüedad de empresa	40.9%	27.3%	31.8%	100.0%
	% dentro de Clústeres	16.4%	14.6%	17.1%	16.1%
	% del total	6.6%	4.4%	5.1%	16.1%
Total de casos	Recuento	55	41	41	137
	% dentro de Antigüedad de empresa	40.1%	29.9%	29.9%	100.0%
	% dentro de Clústeres	100.0%	100.0%	100.0%	100.0%
	% del total	40.1%	29.9%	29.9%	100.0%

Si se analizan las *startups* en función a su antigüedad, de las 56 empresas que tienen tres o menos años de antigüedad, el 14.3% (8) pertenecen al *CC*, el 32.1% (18) pertenecen al CS y el 53.6% (30) pertenecen al *CI*. De las 25 empresas que tienen entre tres y cinco años de antigüedad, el 44% (11) pertenecen al *CI,* el 36% (9) al CC y el 20% (5) al CS. Por otro lado, de las 34 *startups* que tienen entre seis y diez años de antigüedad, el 50% (17) pertenecen al CC, el 35.3% (12) al CS y 14.7% (5) al CI. Finalmente, de las 22 *startups* que tienen más de diez años de antigüedad, el 31.8% (7) pertenecen al CC, 27.3% (6) al CS, mientras que el 40.9% pertenece CI. Cabe resaltar que, para todas aquellas *startups* que tienen tres o más años de antigüedad, el número de "*startups en etapa de crecimiento*" es mayor que el número de "*startups en etapa de supervivencia*".

Por otro lado, la mayoría de las *startups* con cinco o menos años de antigüedad, se encuentran en el clúster de "*startups* en etapa inicial" y lo mismo sucede con las *startups* con más de diez años de antigüedad. Finalmente, la mayoría de las *startups* que tienen entre seis y diez años de antigüedad se encuentran en la "etapa de crecimiento", en la que el factor material tiene mayor influencia en el crecimiento y desarrollo de la misma.

b) *Sector productivo*

Al hacer un análisis por "sector productivo", como se observa en la Tabla 9, el 50% (9) de las *startups* del sector "agricultura, pesca y apícola" y el 62.5% (5) de las *startups* del sector "educación" se encuentran en el CS, es decir, en el que menor valor da a ambos componentes. Por el contrario, más del 50% (17) de las *startups* del sector "industria y manufactura" y el 50% (4) de las *startups* de los sectores "comercio" y "suministro de agua, electricidad, vapor y gestión de residuos" se encuentran en el CI.

Tabla 9. Tabla cruzada "Sector Productivo" y Clústeres

Tabla cruzada "sector productivo" * Clústeres					
Sector productivo		***Startups* agrupadas por clústeres**			**Total**
		"*Startup* en etapa inicial" CI	**"*Startup* en etapa de supervivencia" CS**	**"*Startup* en etapa de crecimiento" CC**	
Agricultura, pesca y apícola	Recuento	5	9	4	18
	% dentro de Sector Productivo	27.8%	50.0%	22.2%	100.0%
	% dentro de Clústeres	9.1%	22.0%	9.8%	13.1%
	% del total	3.6%	6.6%	2.9%	13.1%
Industria y manufactura	Recuento	17	2	10	29
	% dentro de Sector Productivo	58.6%	6.9%	34.5%	100.0%
	% dentro de Clústeres	30.9%	4.9%	24.4%	21.2%
	% del total	12.4%	1.5%	7.3%	21.2%
Comercio	Recuento	4	2	2	8
	% dentro de Sector Productivo	50.0%	25.0%	25.0%	100.0%
	% dentro de Clústeres	7.3%	4.9%	4.9%	5.8%
	% del total	2.9%	1.5%	1.5%	5.8%
Información y comunicaciones	Recuento	7	4	8	19
	% dentro de Sector Productivo	36.8%	21.1%	42.1%	100.0%
	% dentro de Clústeres	12.7%	9.8%	19.5%	13.9%
	% del total	5.1%	2.9%	5.8%	13.9%
Servicios profesionales, científicas y técnicos, financieras, de transporte, de turismo	Recuento	18	16	15	49
	% dentro de Sector Productivo	36.7%	32.7%	30.6%	100.0%
	% dentro de Clústeres	32.7%	39.0%	36.6%	35.8%
	% del total	13.1%	11.7%	10.9%	35.8%
Educación (enseñanza)	Recuento	1	5	2	8
	% dentro de Sector Productivo	12.5%	62.5%	25.0%	100.0%
	% dentro de Clústeres	1.8%	12.2%	4.9%	5.8%
	% del total	0.7%	3.6%	1.5%	5.8%
Suministro de agua, electricidad, vapor, gestión de desechos	Recuento	3	3	0	6
	% dentro de Sector Productivo	50.0%	50.0%	0.0%	100.0%
	% dentro de Clústeres	5.5%	7.3%	0.0%	4.4%
	% del total	2.2%	2.2%	0.0%	4.4%
TOTAL	Recuento	55	41	41	137
	% dentro de Sector Productivo	40.1%	29.9%	29.9%	100.0%
	% dentro de Clústeres	100.0%	100.0%	100.0%	100.0%
	% del total	40.1%	29.9%	29.9%	100.0%

En el caso de las empresas del sector información y comunicaciones, el 42.1% (8) pertenecen al CC en el que el factor material es más valorado, mientras que el 36.7% (18) de las empresas del sector servicios pertenecen al CI en el que ambos componentes son valorados. Cabe señalar que, en el sector servicios, las 49 *startups* se distribuyen casi uniformemente entre los tres clústeres.

Discusión

Los resultados muestran que, las acciones más valoradas por los emprendedores encuestados son: la existencia de un mercado atractivo, el acceso a tecnología y la existencia de fondos concursables. Esto coincide con otros estudios de la región (Kantis et al., 2018), según los cuales, en economías emergentes y ecosistemas incipientes, el acceso a una tecnología que permita desarrollar productos o servicios competitivos, el acceso a un mercado que permita crecer rápidamente de manera orgánica y el financiamiento del Estado en la etapa inicial del emprendimiento dinámico, son condiciones fundamentales para el crecimiento y desarrollo de *startups*, pues los fondos provenientes de la inversión ángel o capitales de riesgo, probablemente estén en fase de formación. Sin embargo, en ecosistemas de emprendimiento y economías con mayor nivel de desarrollo, el acceso a servicios de mentoría, financiamiento y *networking* son más valorados por los emprendedores (Spigel, 2015).

Por otra parte, la existencia de aceleradoras, incubadoras, inversionistas de alto riesgo y espacios de *coworking*, fueron poco valorados. No se conocen las razones de esta baja valoración, sin embargo, por ser un ecosistema de emprendimiento en etapa incipiente, es posible suponer que el conocimiento de los emprendedores, sobre estos actores y sus roles en el proceso de emprender, así como los vínculos entre ellos, sean limitados (Landström, Mason, & Romaní, 2016; Mason & Brown, 2014).

No obstante, como sostienen Brown y Mason (2017), en ecosistemas de emprendimiento *embrionarios* –como es el caso de Lima–, las acciones suelen estar orientadas a promover el emprendimiento y el surgimiento de nuevas iniciativas empresariales, más que a impulsar el crecimiento de las *startups* y la calidad de los emprendimientos. Por eso, se requiere un gran esfuerzo por parte del emprendedor, quien deberá validar su propuesta y conseguir los recursos necesarios para seguir creciendo a través del mercado, más que con el apoyo de redes de inversionistas ángeles, fondos públicos o alianzas con corporaciones. En consecuencia, es necesario que los gestores de programas e instrumentos para el desarrollo de ecosistemas de emprendimiento, tengan clara la distribución de *startups* por antigüedad, por sector al que pertenecen y la fase de emprendimiento en la que se encuentran, para que identifiquen los componentes que podrían incidir en su crecimiento (Spigel, 2015).

Con respecto a los componentes identificados, si se comparan los resultados con los atributos sociales y materiales planteados por Spigel (2015), de las ocho variables agrupadas en el componente I, cuatro (V5, V6, V7 y V8) corresponden al atributo "social" y cuatro (V1, V3, V4, y V11) al atributo "material"; mientras que en el componente II, las cuatro variables corresponden al atributo "material" planteado por Spigel (ver tabla 10). En ecosistemas incipientes, con recursos escasos, es de esperar que el acceso a algunos recursos, dependa más de la red de contactos del emprendedor que de la disponibilidad de recursos en el ecosistema.

Tabla 10. Comparación de los resultados del análisis de componentes principales con modelo de Spigel

Atributos Modelo de Spigel (2015)	**Resultados ACP**	**Descripción de variable en estudio**
(M2) Servicios de apoyo e infraestructura	Social	(V3) La existencia de aceleradoras
(M2) Servicios de apoyo e infraestructura	Social	(V4) La existencia de incubadoras
(S2) Capital emprendedor	Social	(V5) La existencia de inversionistas de alto riesgo
(M2) Servicios de apoyo e infraestructura	Social	(V11) La existencia de *coworkings* gratuitos
(S3) Mentores y modelos a seguir	Social	(V8) Apoyo por parte de mentores
(S1) Redes sociales	Social	(V6) Visitas a otros ecosistemas internacionales
(S3) Mentores y modelos a seguir	Social	(V7) Apoyo por parte de otros emprendedores
(M3) Políticas y gobierno	Social	(V1) La existencia de fondos concursables
(M2) Servicios de apoyo e infraestructura	Material	(V12) Acceso a tecnología
(M1) Universidades	Material	(V10) Acceso a universidades y especialistas
(M3) Políticas y gobierno	Material	(V9) Acceso a laboratorios y centros de investigación
(M4) Mercados abiertos	Material	(V2) La existencia de un mercado atractivo

Social = Componente 1 Material = Componente II

Con el fin de explorar si el financiamiento que el Estado estaba brindando a las incubadoras, aceleradoras, redes de inversionistas ángeles y fondos concursables, contribuía con el crecimiento y desarrollo de las *startup*s, el atributo "servicios de apoyo e infraestructura" (M2) propuesto por Spigel se desagregó en el cuestionario. Los resultados mostraron muy bajas valoraciones de estas variables, lo que valdría la pena profundizar en estudios posteriores.

En un ecosistema de emprendimiento incipiente (Kantis et al., 2017), con reducido número de actores, pocos emprendimientos dinámicos e innovadores y falta de políticas de apoyo al emprendimiento dinámico, es de esperarse una baja valoración de los componentes. Sin embargo, los clústeres han evidenciado las distintas necesidades de los emprendedores en función a la fase de crecimiento y desarrollo en la que se encuentran. Cabe resaltar la importancia del componente material –acceso a tecnología, universidades y especialistas, laboratorios y centros de investigación, además de la existencia de un mercado atractivo– para las *startups* en las etapas inicial y de crecimiento. En estas etapas, es probable que el acceso a recursos intangibles como el "conocimiento" –vinculado a la tecnología, talento, registros de patentes y oportunidades de mercado– tenga mayor influencia en el crecimiento y desarrollo de la *startups*, porque contribuyen directamente a su competitividad.

El análisis de clústeres y las tablas cruzadas permitió identificar que, en etapas iniciales, ambos componentes son relevantes para el crecimiento y desarrollo de *startups.* En este clúster la presencia de actores del ecosistema (incubadoras, aceleradoras, inversionistas, otros emprendedores, gobierno, academia) y el acceso a sus recursos (científicos, tecnológicos, financieros, conocimiento, talento y mercado) son valorados, especialmente por aquellos que están en los sectores de "industria y manufactura", "comercio", "servicios profesionales, científicos y técnicos, financieros, de transporte y de turismo" y "suministro de agua, electricidad, vapor y gestión de desechos".

Por el contrario, las 41 *startups* en etapa de supervivencia, valoran poco los atributos sociales y materiales, y los sectores con mayor representatividad en este clúster son "agricultura, pesca y apicultura" y "educación".

Con respecto a las 41 *startups* en "etapa de crecimiento" estas valoran el tributo material, mas no el social. Es probable que esto se deba a que 58.5% de s*tartups* tienen seis o más años de antigüedad, en cuyo caso, la existencia de incubadoras, aceleradoras*, coworkings*, inversionistas, fondos del Estado, visitas a ecosistemas de emprendimiento internacionales y el apoyo de mentores sea poco o nada valorado. Por el contrario, estas *startups* valoran el acceso a tecnología, universidades y especialistas, laboratorios y centros de investigación, así como la existencia de una demanda atractiva. Es posible suponer que, para estas *startups*, los recursos intangibles como el conocimiento y acceso a nuevos mercados, sea más valorado que el atributo social. Cabe resaltar que el único sector cuya mayor proporción de *startups* está en este clúster es el de "información y comunicaciones".

Con respecto a la caracterización de las *startups* en función al sector productivo, "educación" y "agricultura, pesca y apícola" son los que menor puntuación dieron a la influencia de los componentes –social y material–, mientras que las *startups* de los sectores "servicios profesionales, científicos, técnicos, financieros, de transporte y de turismo", "industria y manufactura" e "información y comunicaciones" son los que mayor valor dieron a ambos componentes. Estos resultados sugieren que el ecosistema de emprendimiento de Lima, por sus características económicas, geográficas, demográficas y socioculturales, probablemente aporte más al crecimiento y desarrollo de *startups* de los sectores secundario y terciario de la economía, que a otro tipo de sectores productivos.

Como sugieren Spigel y Harrison (2018), desde la perspectiva del *desarrollo de los ecosistemas de emprendimiento,* en una etapa inicial, los ecosistemas deberían brindar acceso a recursos materiales y apoyar en la vinculación entre los diversos actores, lo que es fundamental para el surgimiento y supervivencia de las *startup*s. Sin embargo, en una etapa de mayor madurez del ecosistema, los diversos actores deberían ofrecer recursos para un crecimiento acelerado y un mayor desarrollo –productivo y competitivo– de las *startup*s.

Finalmente, es importante evaluar si para países emergentes como Perú, con ecosistemas de emprendimiento incipientes, los programas o instrumentos de apoyo al desarrollo de ecosistemas de emprendimiento están favoreciendo el crecimiento acelerado y la mayor competitividad de *startups*, o más bien, están alargando la agonía de *startups* poco productivas y competitivas. En este sentido, las políticas de apoyo al emprendimiento y los programas de apoyo para la competitividad deberán considerar los recursos y capacidades de los emprendedores, de sus *startups*, de los diversos actores del ecosistema y el contexto más general –a nivel macro– que condiciona la competitividad de las *startups*.

Conclusiones

Para los formuladores y gestores de políticas públicas, es importante conocer y monitorear las necesidades de los emprendedores de *startups,* con el fin de que los escasos recursos públicos, sean asignados eficientemente y no se desperdicien tratando de reproducir condiciones o conceptos que han sido exitosos en otros contextos, bajo condiciones económicas, culturales, geográficas y sociodemográficas distintas.

Para el caso específico del ecosistema de emprendimiento de Lima, se requiere desarrollar el componente social, para llevar a las *startups* de una situación inicial de supervivencia, a un crecimiento acelerado. Pero también es necesario desarrollar el componente material, para acelerar el crecimiento y mejorar la productividad y competitividad de las *startups*, es decir, la calidad de los emprendimientos, más que la cantidad de los mismos.

En ecosistemas incipientes, de países emergentes, los programas de apoyo del Estado y un mercado atractivo contribuyen al crecimiento y desarrollo de *startups*, lo que coincide con el estudio de otros ecosistemas de emprendimiento en etapa embrionaria como Estonia (Saarenketo, Torkkeli, & Velt, 2018). En este tipo de ecosistemas, si bien algunos actores podrían tener mayor incidencia que otros, como por ejemplo las instituciones del gobierno sobre las incubadoras, o un mercado atractivo sobre la existencia de redes de inversionistas ángeles, no hay un solo tipo de actor que dirija las actividades del ecosistema. Quizás por ello, la valoración de los emprendedores da como resultado una distribución no paramétrica de las variables estudiadas, lo que sugiere el nivel de desarrollo del ecosistema (Albort-Morant & Oghazi, 2016). Sin embargo, la poca valoración dada a algunos actores, podría estar vinculada a la poca presencia o la baja calidad de sus servicios.

En países emergentes como el Perú, con graves deficiencias en el sistema educativo, limitada plataforma de CTI e I+D y una cultura de innovación poco desarrollada (Kantis et al., 2018; OCDE, 2016), la competitividad de las *startups* es un reto, a pesar de contar con una fuerte cultura orientada al emprendimiento (Serida, Alzamora, Guerrero, Borda, & Morales, 2018) y condiciones macroeconómicas y de mercado, favorables (Banco Central de Reserva del Perú, 2019). En estas circunstancias, se requiere un mayor desarrollo del componente material –acceso a la tecnología, acceso a universidades y especialistas, acceso a laboratorios y centros de investigación, y la existencia de un mercado atractivo–, pues el componente social –apoyo por parte de los diversos actores del ecosistema y acceso a financiamiento– por sí mismo no es suficiente. La incidencia del componente material en el crecimiento y desarrollo de *startups* evidencia la necesidad de diseñar incentivos y políticas que promuevan y estimulen la inversión –pública y privada– en actividades de innovación.

Finalmente, si bien se trata de un estudio exploratorio, los resultados brindan información relevante a los formuladores de políticas públicas y los gestores de programas e instrumentos de apoyo para *startups.* Se espera que esta información contribuya a la eficiencia del gasto público, y que los gobiernos regionales y locales "construyan" y "nutran" sus propios ecosistemas de emprendimiento, de acuerdo con la naturaleza específica de cada territorio y el perfil de sus emprendimientos (Feld, 2012), más que con "recetas exitosas" de otros contextos.

Recomendaciones

Se recomienda profundizar el estudio exploratorio incluyendo: i) un análisis de variables culturales, como la perseverancia y la ambición de los emprendedores o la disponibilidad de capital humano motivado a trabajar en una *startup*; y ii) ampliar la muestra a una mayor diversidad de emprendedores, no solo *startups* que tuvieron algún acercamiento al programa de financiamiento para el emprendimiento y la innovación de Innóvate Perú, sino también empresas de rápido crecimiento (*High Growth Firms*).

Se recomienda replicar el estudio en el resto de ciudades en las que Innóvate Perú ha otorgado fondos para el desarrollo de los ecosistemas de emprendimiento e innovación, como hizo previamente en la ciudad de Lima. Ello permitirá caracterizar las *startup*s de cada localidad, comparar los resultados, hacer propuestas específicas y evaluar la eficiencia de los programas e instrumentos para el desarrollo de ecosistemas de emprendimiento en cada localidad. Sin embargo, se debe considerar que, en algunas zonas rurales, se podrían encontrar ciertas limitaciones de la comunidad para involucrarse en la construcción del ecosistema de emprendimiento, por falta de capacidades físicas, humanas y financieras. Ello podría limitar su construcción y desarrollo, y por lo tanto el apoyo del ecosistema a la competitividad de las *startups* se vería limitado.

Implicancias para hacedores de políticas y administradores

Conocer los componentes o atributos del ecosistema de emprendimiento de Lima que inciden en los tres clústeres identificados es importante y relevante para poder alinear el apoyo a las *startups* con una estrategia de transformación productiva y de innovación más amplia.

La incidencia del atributo material en el crecimiento y desarrollo de *startups,* evidencia la necesidad de diseñar incentivos y políticas que promuevan y estimulen la inversión –pública y privada– en actividades de innovación y en políticas de innovación y desarrollo productivo. En este sentido, es necesario alinear las políticas de: fomento para *startups*, fortalecimiento de los actores y desarrollo de ecosistemas de emprendimiento, con políticas de innovación y transformación productiva, pues las probabilidades de éxito de una *startup* dependen de las capacidades para innovar y emprender, así como de las relaciones entre todos los actores de un distrito industrial o ecosistema.

Reconocer la importancia de las *startups* para el progreso económico y bienestar social de una localidad, implica reconocer que para medir su aporte se deben usar métricas distintas al número de empresas que surgen o mueren. Indicadores como tasa mensual de crecimiento en ingresos o número de clientes, incursión en nuevos mercados, desarrollo de nuevos productos, número de registros de propiedad intelectual y nivel de satisfacción de los clientes o usuarios, suelen ser más eficientes para medir el nivel de innovación y escalabilidad de las *startups.* Además, es recomendable establecer sistemas de acreditación de la calidad de los servicios ofrecidos por los diversos actores, en función al impacto en la *startup.* De esta manera, se estaría evitando que los actores del ecosistema se conviertan en "captadores de recursos" con baja eficiencia.

El ecosistema de apoyo a las *startups* de Lima está pasando de una etapa de "gestación y experimentación" con una lógica de "piloto", a una etapa de "consolidación o expansión" con una lógica de "escalamiento" en Lima y otras regiones (OCDE, 2016). Por ello, requiere de programas de apoyo ágiles y dinámicos, capaces de dialogar con inversionistas y empresarios; mientras que el sistema de innovación, que dialoga con investigadores, académicos y corporaciones, suele ser menos ágil (OCDE 2017). En general, en Latinoamérica, el dinamismo de las políticas, programas e instrumentos de apoyo para de desarrollo de ecosistemas de emprendimiento ha sido mayor que las intervenciones más tradicionales de apoyo a la innovación y competitividad (OECD, 2016a).

Las probabilidades de éxito de una *startup* dependen de las capacidades para innovar y emprender, y de las relaciones entre los actores de un clúster o ecosistema, que la ayuden a elegir e implementar una estrategia (Murray & Stern, 2015). Por ello, fortalecer la cultura empresarial y la cultura de innovación son aspectos fundamentales para el crecimiento y desarrollo de las *startups.*

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Assessing the Impacts of Market Failures on Innovation Investment in Uruguay

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Abstract: This paper analyzes the effects of financial and nonfinancial obstacles to innovation on Uruguayan firms. We contribute to the literature by including the role of systemic and institutional factors affecting the different stages of the innovation process. The empirical analysis is based on four waves of national innovation surveys covering firms in the industry and services sector. In line with recent studies, we confine our analysis to the relevant sample of potentially innovative firms. Our results show that market, financial, knowledge, and context obstacles are the most important factors reducing innovation propensity and the amount invested in innovation activities. The effects are similar for firms in the industry and services sectors. We do not find evidence that institutional factors hamper innovation. Investment in equipment and investment in R&D and other intangible activities are affected differently by obstacles. On the other hand, innovation outcomes are affected mainly by financial and market-related barriers. We do not find evidence that obstacles to innovation have a significant impact on labor productivity.

Keywords: CDM model; financial and non-financial barriers to innovation; innovative firms; Uruguay

1. Introduction

In the last century, theoretical and empirical works have identified innovation (mainly proxied by R&D investment) as a key driving force of firm productivity and economic growth. Theoretically, since the pioneering work of Solow (1957), technological change has been credited with explaining a substantial share of economic growth, while empirical developments focusing on the relationship between R&D expenditure and productivity have flourished since the seminal work of Griliches (1979). Since then, several Latin American and Caribbean (LAC) countries have established and implemented public policies aimed at enhancing innovation (Crespi and Dutrénit, 2014). However, while much attention was paid to the determinants of firm's innovation and the impact of the policy actions to promote innovation on investment and firm productivity, the analysis of the factors behind the lack of engagement on innovation activities has been neglected.

Even though there are several studies that focus on innovation and Science and Technology (STI) policies in Uruguay (Bernheim et al., 2014; Aboal et al., 2015; Bukstein et al., 2017, among others), none of them focus on what prevents the firm from engaging in innovative activities or obtaining results from their innovation efforts. As Bianchi, Bianco, and Snoeck (2014) point out, Uruguayan policymakers lack information about obstacles hampering innovation in productive sectors. Exploring the factors hampering innovation is relevant in the design of policy interventions and the national systems of innovation (Woolthius, Lankhuizen, and Gilsing, 2005). The proper identification of which obstacles affect each part of the innovation process could encourage specific interventions that may lead to an increase in economic growth and development in the long run. In that sense, we expect that the evidence presented in this paper will become a key input in the future design of policy actions.

The main objectives of this study are: (i) to test and measure to what extent barriers hinder innovation in a developing country such as Uruguay, with a focus on context and institutional barriers; (ii) to compare whether the severity of the barriers vary across different economic sectors; and (iii) to compare whether barriers are relatively more important for tangible investments than intangible ones. We add to the literature of barriers to innovation in two ways. On the one hand, we analyze the effect of barriers to innovation on the entire chain of the innovation process: innovation propensity, innovation intensity, innovation outputs, and labor productivity. We do so separately for firms in the industry sector and the services sector. Secondly, we introduce a specific variable to measure how the institutional context affects the innovation process. This intends to shed some light on the effects of regulation and systemic factors affecting the firms' innovative behavior. We use a novel dataset covering all industries and some services of firms in the Uruguayan economy, which allows us to investigate the heterogeneous effects of barriers by sector and type of innovation.

We report that barriers to innovation have a substantial effect on innovation propensity, innovation intensity, and innovation outcomes. On the other hand, we do not find evidence that barriers affect labor productivity. The presence of obstacles to innovation translates to a reduction of 47 percent to 89 percent in the firms' innovation efforts; also, it translates to a reduction of 6.5 percent to 14 percent in the firms' innovation propensity. Financial, market, knowledge, and context obstacles are the most important factors distressing the innovation process, as they reduce the probability of engaging in innovation activities and the amount invested as well as innovation outcomes. The results indicate that barriers affect firms in the industry and services sector in a similar way.

The paper proceeds as follows. Section 2 provides a brief review of the recent developments in the literature on barriers to innovation. In Section 3, we introduce the data and methodological aspects of the paper. Section 4 shows the results of the econometric exercises; in section 6 we discuss the implications of our results. Finally, Section 6 concludes.

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2. Literature Review

The empirical literature analyzing obstacles to innovation in the past decades was dedicated mostly to the role of financial constraints (Himmelberg and Petersen, 1994; Bond, Harhoff, and Van Reenen, 1999; Hall, 2002; Hall, 2008). Most of these papers use data on investment and cash flows and measure the effects of financial obstacles on innovation indirectly through the sensitivity between the latter and the former. This strand of the literature highlights that the intrinsic degree of uncertainty that characterizes innovation projects, together with their complexity, makes firms less likely to invest in innovation in the absence of financial availability (Hottenrott and Peters, 2012). Other recent contributions in this line use innovation survey data and provide direct information on the role of financial obstacles. Most of these studies are based on data from the European Community Innovation Survey (CIS) and Canadian data. Tourigny and Le (2004) study the perception of these obstacles among Canadian SMEs. Savignac (2008) finds that financial constraints and weak access to credit significantly reduce the likelihood of introducing new innovations, while Canepa and Stoneman (2007) find that the effects of credit constraints vary between sector and dimension of firms in the United Kingdom. Mancusi and Vezzulli (2010, 2013) measure the effects of financial constraints in R&D investment in Italy. An important feature of innovation survey data that attracted the attention of scholars to this area of study is that it allows for a direct measure of the perception of obstacles by the firms. In this line, Mohnen and Rosa (2001) try to explain why Canadian firms perceive the obstacles to innovation differently. Galia and Legros (2004) study the perception of obstacles and complementarities in France.

More recent studies widened the scope of the analysis as they included in the picture obstacles not related to finance such as market structure, demand uncertainty, and lack of skilled personnel, among others (Iammarino, Sanna-Randaccio, and Savona, 2009; D'Este et al., 2012; D'Este, Rentocchini, and Vega-Jurado, 2014; Segarra-Blasco, García-Quevedo, and Teruel-Carrizosa, 2008; Pellegrino and Savona, 2017). Methodologically, there has been a turning point in the literature with the definition of the "relevant sample" of firms willing to innovate. A large part of the empirical literature, including studies mentioned above, finds a counterintuitive positive correlation between innovative behavior and obstacles to innovation (Mohnen and Rosa, 2001; Baldwin and Lin, 2002; Galia and Legros, 2004). Each of these studies tried to make sense of these counterintuitive findings in different ways, but they all converge in the concept of "revealed barriers," which implies that the more a firm participates in the innovation process, the more aware of the obstacles it becomes. However, recent papers (D'Este et al., 2012; Pellegrino and Savona, 2017) provide a more convincing mechanism to tackle this issue and generate consistent results, which involves excluding the firms not willing to innovate from the sample used in the empirical exercises. In the next section, we explain the construction of the relevant sample in this paper following this procedure.

Another important feature of recent literature that analyzes the role of a broad measure of obstacles and that we will address in the present study is the inclusion of the concept of "systemic failure." This concept arises when considering that not only financial barriers but also many other factors hinder innovation efforts. Consequently, the problem is not concentrated in a particular sector (e.g., financial markets), but expanded along with the economy and the national system of innovation as a whole. In that sense and according to Coad, Pellegrino, and Savona (2016), "the presence of barriers to innovation is not just the result of a 'market failure' problem, rather it might be associated with particular conditions that represent 'systemic failures' for firms, which are difficult to overcome and might be seriously detrimental to their innovation and productivity performance, making the topic of substantial policy relevance." Following D'Este, Rentocchini, and Vega-Jurado (2014), we define systemic failures in terms of the extent to which institutional factors weaken the capabilities of the firms to engage in innovative activities. Systemic failures to innovation include: (i) the lack of institutional support for innovation; (ii) the lack of information on technological and market opportunities for innovation; (iii) the lack of adequate infrastructure; and (iv) market structure factors.

Finally, regarding obstacles to innovation in Latin America, the evidence is scarce. Álvarez and Crespi (2015) use innovation surveys to measure the effect of financial constraints on innovation using a sample of Chilean firms. They find that financial barriers are quantitatively important, especially for firms operating in the services sector. Mohan, Stroble, and Watson (2017) measure the effects of obstacles on innovation propensity, intensity, innovation outcomes, and labor productivity using a sample of Caribbean firms. They find that cost, knowledge, market, and policy obstacles hamper engagement in innovation activities, innovation investment, and innovation outcomes. However, they do not find that obstacles reduce labor productivity.

3. Data and Methodology

3.1. Dataset

The data used in this paper comes from national Innovation Surveys (IS). IS is one of the largest-scale surveys gathering information on innovation behavior and outcomes. The IS in Uruguay has been carried out every three years since 1998 and is conducted by the National Bureau of Statistics (INE) as a request by the National Agency for Research and Innovation of Uruguay (ANII). The first waves only included firms in the manufacturing industry. Since the 2004–06 wave, the IS has included firms from some services sectors.

The universe of study is firms that employed at least five people or had sales greater than or equal to 120 million pesos (current USD 4.2 million) in the period. Since 2004 the IS includes the following sectors (based on ISIC Rev.4): manufacturing; electricity, gas, steam, and air-conditioning supply; water supply, sewerage, waste management and remediation activities; transportation and storage; accommodation and food service activities; information and communication; professional, scientific, and technical activities; administrative and support service activities; and human health and social work activities. Table A1 in the Appendix shows the sectoral composition of the firms.

The empirical analysis will be based on a panel data of firms from the IS observed in all periods: 2004–06, 2007–09, 2010–12, 2013–15. As we observe all firms across all years we work with a balanced panel. The decision to use a balanced panel is because the sample design that the INE uses, which is a rotating panel. That is each wave of the survey. The statistics bureau follows the larger part of the sample while randomly rotating approximately 25% of the sample ensuring that ISIC sector representation is maintained. While the random nature of the attrition would make the unbalanced version of the panel almost equivalent to the balanced panel in terms of its econometric treatment (Wooldridge, 2010), we choose to work with the balanced version in order to focus in the theoretical and empirical implication of the regressions, leaving aside the treatment of the sample selection that arises in these cases.

The panel data comprises a set of general information (main industry of affiliation, turnover, employment, and founding year) and a broader set of innovation variables measuring the firms' engagement in innovation activity, economic measures of the effects of innovation, subjective evaluations of factors hampering or fostering innovation, cooperative innovation activities, organizational innovation, and marketing. While general information on the firm was requested for each year in the surveys of 2010–12 and 2013–15 and for the last year of the survey for 2004–06 and 2007–09, innovation engagement variables are requested for the whole period. Therefore, while for the continuous variables, we have eight years of information, the innovation-related variables are requested in such a fashion that we can only build a four-period panel. In order to adjust the span of the variables, we take the 2010–12 and 2013–15 averages of the general information variables when necessary so that we have four periods of data for them.

3.2. Sample Selection of Innovative Firms

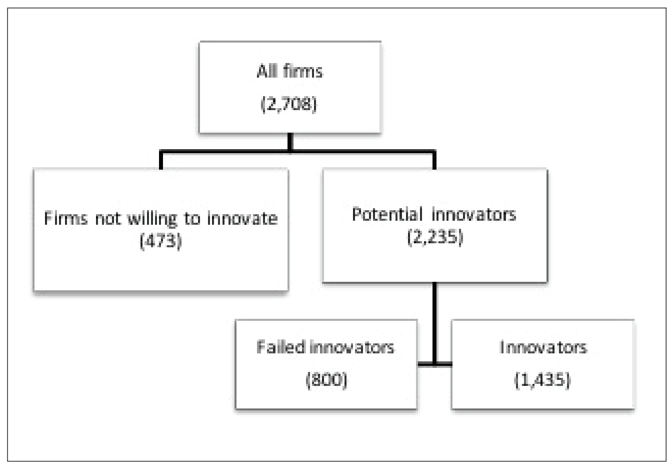
As mentioned above, the definition of the relevant sample of firms to be included in the empirical analysis has become a milestone in the literature of barriers to innovation. Savignac (2008), D'Este et al. (2012), Blanchard et al. (2012), and Pellegrino and Savona (2017) have shown that filtering out firms that do not want to innovate removes the positive correlation found between firms' innovation efforts and obstacles to innovation found in earlier papers such as Baldwin and Lin (2002) and Iammarino, Sanna-Randaccio, and Savona (2009). Hence, we will follow these recent developments and confine our analysis to the relevant sample of potential innovators that either engaged in innovation activities (reported non-zero innovation investment) or reported at least one barrier to the innovation of "high importance." Three categories of firms were identified in terms of their innovative status:

1. Innovative firms: reported non-zero innovation investment regardless of whether they faced obstacles to innovate
2. Failed innovators: reported at least one barrier as important but did not report innovation investment
3. Firms not willing to innovate: did not report any barriers nor do they engage in innovation activities

In order to correctly estimate the sign and size of the relationship between innovation and barriers to innovation, the relevant sample included innovative firms and failed innovators, and excluded firms not willing to innovate. The raw database includes 690 firms and 2,760 firm-year observations. We exclude from these firms 11 publicly owned companies because, as Table A2 in the Appendix shows, they are much larger than the rest of the firms and also because the fundamentals of innovation investment spending in state-owned companies differ from private companies so the effects of barriers to innovation can be expected to be different as well.[1] After excluding publicly-owned firms and observations that do not fall under the relevant sample, we end up with a panel of 2,235 firm-year observations that fall under one of the three categories defined above. Figure 1 shows the distribution of the observations regarding their status in the sample. Almost 83 percent (2,235) of total observations are included in the relevant sample. Within the innovative sample of firms, 1,435 reported investments in innovation activities, while 800 declared to have faced at least one barrier to innovation while they did not engage in innovation activities.

It is important to stress that even though we correct for this known source of bias, other sources of endogeneity may emerge, for example, if successful innovators and failed innovators value the importance of obstacles to innovation differently. Also, it is important to note that, as in most micro-panels that follow enterprises over the years, our sample shows a moderate bias towards larger firms that survive along the four periods of the IS. Therefore, the results should be interpreted accordingly. Next, we detail our definitions of the barriers to innovation to be included in the empirical analysis.

Figure 1: Selection of the Relevant Sample



Source: Author's elaboration.

3.3. Obstacles

The IS questionnaire asks about 14 different obstacles to innovation. Firms are asked to respond in a 1 to 4 Likert-type scale if each obstacle was of an irrelevant, low, medium, or high importance in the process of trying to perform innovation activities, with 1 being high importance and 4 irrelevant. In this paper we will define that a firm declares the obstacle is present if it is declared as being of high importance.

[1] In Uruguay, state-owned enterprises are an important part of the government instruments to execute public policy and are mostly monopolies. Therefore, the rationale of the innovation decisions in these firms and the obstacles faced by them may not be comparable with those of the firms in the private sector.

Note that the questionnaire asks about a broad number of factors that may have affected the innovation process. Using all of these separately would result in the construction of 14 obstacles variables. However, we choose to work a more parsimonious approach and build five dummy variables that take the value of 1 if firms faced barriers to innovation related to: 1) financial factors, 2) knowledge factors, 3) market size and structure factors, 4) institutional STI factors, and 5) context.

1. Financial obstacles: Dummy = 1 if the firm indicates the following barriers as being of high importance: cost of finance, excessive economic risks, return period of investment risks, and 0 otherwise.
2. Knowledge obstacles: Dummy = 1 if the firm indicates high importance in the following barriers: lack of qualified personnel, lack of information on technology, lack of information on markets, organizational rigidity, poor cooperation possibilities with other firms/institutions, and 0 otherwise.
3. Market size and structure obstacles: Dummy = 1 if the firm indicates the following barriers as being of high importance: reduced market size, few technological opportunities of the sector, and 0 otherwise.
4. Institutional STI obstacles: Dummy = 1 if the firm indicates the following barriers as being of high importance: insufficient development of institutions related to science and technology, poor intellectual property system, and 0 otherwise.
5. Context obstacles: Dummy = 1 if the firm indicates the following barriers as being of high importance: inadequate infrastructure, macroeconomic instability, and 0 otherwise.

3.4. Econometric Model and Empirical Implementation

The methodology builds largely on Crespi and Zuñiga (2012) and Mohan, Stroble, and Watson (2017). Given that our goal is to measure the effect of obstacles to innovation on innovation propensity, innovation intensity, innovation outputs, and labor productivity, we need a model that captures the complex relationships between these variables. Therefore, we adapt the CDM model (Crepon, Duguet, and Mairesse, 1998) with the explanatory variables used in the recent literature of obstacles to innovation. The model consists of a system of five equations linking a firm's innovation activities investments to its innovation output, and its innovation output to productivity. The CDM model allows us to deal with the selection bias in the innovation effort that results from the definition of the relevant sample, as the firms that invest in innovation activities can be thought of as a non-random sample of the firms. Empirically, we estimate the model sequentially in three steps. We begin by modeling the firms' innovation effort IE^* by:

$$IE^* = \beta_1 Z + \beta_2 X_1 + \varepsilon_1 \quad (1)$$

where is a latent variable accounting for desired expenditures in innovation activities, the vector of obstacles to innovation defined above, and a vector of other covariates that explain expenditure in innovation activities. We proxy innovation effort using (log) total expenditure in innovation activities per worker as our dependent variable but we also distinguish between (log) expenditure in tangible activities per worker (expenditure in machinery, hardware, and software for innovation) and (log) expenditure in intangible activities (R&D, technology transfers, industrial design and engineering, organizational design, training, and market research). Next, we introduce a selection equation that models the probability of observing investment in innovation activities:

$$ID = \begin{cases} 1 \text{ if } ID^* = \beta_1 Z + \beta_2 X_2 + \varepsilon_2 > \alpha \\ 0 \text{ if } ID^* = \beta_1 Z + \beta_2 X_2 + \varepsilon_2 < \alpha \end{cases} \quad (2)$$

where ID is a binary variable that equals 1 if a firm reports investment in innovation activities greater than zero and 0 otherwise. is a latent variable modeling the firm's innovation decision which materializes if it is above the threshold level and where is a vector of barriers to innovation and are vectors of covariates affecting the innovation investment decision analogous to the ones in the previous equation.

As we only observe the amount invested for firms willing to engage in innovation activities, we combine equations (1) and (2) and write:

$$IE = \begin{cases} IE^* = \beta_1 Z_i + \beta_2 X + \varepsilon_1 \text{ if ID} = 1 \\ 0 \text{ if } ID = 0 \end{cases} \quad (3)$$

Assuming that the error terms and are bivariate normal distributed with zero mean, and correlation coefficient we estimate the system of equations (2) and (3) as a type II Tobit model.

The next equation provides the link between investment in innovation activities and innovation results through the so-called "knowledge production function" (Griliches, 1979; Pakes and Griliches, 1984) where the predicted values of the innovation effort enter as one of the covariates in the equation:

$$IO = \gamma IE^* + \beta_1 Z + \beta_3 X_3 + u_i \quad (4)$$

Where IO is an innovation output and IE^* the predicted innovation effort from the previous step. We define three types of innovation outputs: a general definition of innovation, technological innovation (product or process innovation), and non-technological innovation (organizational and marketing). The last equation of the model relates labor productivity with innovation results:

$$y = \varphi IO^* + \beta_1 Z + \beta_4 X_4 + u \quad (5)$$

where y is labor productivity measured by the natural logarithm of sales per employee,[2] IO^* the predicted innovation output from equation (4), and Z the vector of obstacles to innovation.

We estimate this recursive model in the following way. First, we estimate the generalized Tobit model of equations (2) and (3) using the Heckit procedure. Note that in this case we are not using a panel-data specific method of estimation, and we are not including fixed effects; therefore, we control for individual heterogeneity that could bias the estimation as a function of observables following Mundlak's (1978)

[2] Unfortunately, we do not have access to data on capital assets and therefore we cannot measure total factor productivity or include the capital per worker as a covariate as in other papers using the CDM model.

approach including the within means of the explanatory variables (i.e., the average values of the covariates across all time periods for every firm) as regressors. The covariates included in the estimation of (2) and (3) are the natural logarithm of the firm's size measured by the number of employees, the natural logarithm of the firm's age, the proportion of highly skilled workers, and a dummy for exporter status, with the caveat that we remove the (log) size from the innovation effort equation in order to achieve identification because the investment is already scaled for size. We estimate equation (4) using a random-effects probit model also including the within means of the covariates to control for individual time-invariant characteristics of the firms. The additional regressors included in (4) are (log) size, exporter status, and proportion of highly skilled workers. Finally, we estimate equation (5) using a fixed-effects regression. We use the broad definition of innovator in order to calculate the predicted value of *IO* in equation (5). In this equation, the only additional covariate is the (log) size. All regressions include year dummies. In each stage we run the regressions for all the firms in the relevant sample and repeat the exercise separately for the industry and services sector.

3.5. Descriptive Evidence

Tables 1 and 2 show descriptive statistics for the firms in the different sample categories and by sector respectively. In the top panel we describe the dependent variables in the regressions. The data indicate that the average firm in the sample invests USD 2,113 per year per worker in total innovation activities; however, note that the sub-sample of innovators spends twice that figure. Investment in tangible activities is the most important expenditure as it accounts for 85 percent of total investment. It is important to note the large standard deviations in the productivity variable, an issue that will be addressed below. Process innovation is the one with a higher prevalence; 70 percent of innovators successfully introduce these types of innovations. Also note that 98 percent of the firms engaged in innovation activities successfully introduce a technological or non-technological innovation. In the middle panel we report the descriptive statistics for the obstacle's dummy variables, as defined above. The most interesting result lies in the proportion of firms declaring facing obstacles in each sub-sample of innovative firms. The fact that innovators declare consistently lower obstacles than failed innovators is in line with the concept of *deterring barriers* (D'Este et al., 2012), as a larger involvement in innovation activities is associated with lower barriers to innovation. Regarding the explanatory variables, innovators appear older, larger, more export-oriented, and with a higher proportion of skilled workers within the firms. Results in Table 2 indicate that failed innovators and innovators in the industry sector appear to be more constrained by obstacles than firms in the services sector.

Table 1: Descriptive Statistics by Firm Category in the Sample

Dependent Variables	Total Sample			Failed Innovator			Innovator		
	Mean	SD	n	Mean	SD	n	Mean	SD	n
Total investment in innovation activities	2,113	19,088	2,708	0	0	800	3,988	26,083	1,435
Investment in Tangibles	1,796	18,990	2,708	0	0	800	3,390	25,988	1,435
Investment in Intangibles	316	1,195	2,708	0	0	800	597	1,590	1,435
ln (Total investment in innovation activities)	6.48	2.00	1,435				6.48	2.00	1,435
ln (Investment in Tangibles)	6.29	2.08	1,174				6.29	2.08	1,174
ln (Investment in Intangibles)	5.03	2.43	1,120				5.03	2.43	1,120
Productivity	128,014	326,805	2,708	100,311	281,159	800	127,751	247,452	1,435
ln (Productivity)	10.98	1.21	2,708	10.70	1.24	800	11.13	1.11	1,435
Innovator	52%	50%	2,708	0	0	800	98%	14%	1,435
Product	27%	44%	2,708	0	0	800	50%	50%	1,435
Process	37%	48%	2,708	0	0	800	70%	46%	1,435
Organizational	23%	42%	2,708	0	0	800	43%	50%	1,435
Marketing	11%	31%	2,708	0	0	800	21%	40%	1,435
Obstacles									
Financial obstacles	36%	48%	2.708	59%	49%	800	36%	48%	1,435
Knowledge obstacles	32%	47%	2.708	50%	50%	800	33%	47%	1,435
Market obstacles	38%	49%	2.708	60%	49%	800	38%	49%	1,435
Institutional STI	14%	34%	2.708	22%	41%	800	14%	35%	1,435
Context	21%	41%	2.708	34%	48%	800	20%	40%	1,435
Explanatory Variables									
Age	40.43	21.31	2.708	38.62	19.16	800	42.42	22.83	1,435
Size	218.38	484.21	2.708	148.29	285.66	800	277.82	600.57	1,435
ln (Age)	3.56	0.53	2.708	3.53	0.52	800	3.60	0.55	1,435
ln (Size)	4.57	1.19	2.708	4.26	1.14	800	4.83	1.16	1,435
Exporter	0.39	0.49	2.708	0.30	0.46	800	0.46	0.50	1,435
High education	7.87	11.79	2.708	5.92	9.89	800	9.02	11.93	1,435

Source: Authors' calculations.

Table 2: Descriptive Statistics by Sector and Category

Dependent Variables	Failed Innovator						Innovator					
	Industry			Services			Industry			Services		
	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Total investment in innovation activities	0	0	426	0	0	374	3,954	10,567	860	4,038	39,148	575
Investment in Tangibles	0	0	426	0	0	374	3,217	10,300	860	3,651	39,094	575
Investment in Intangibles	0	0	426	0	0	374	737	1,863	860	387	1,023	575
ln (Total investment in innovation activities)							6.93	1.82	860	5.81	2.07	575
ln (Investment in Tangibles)							6.76	1.89	715	5.56	2.16	459
ln (Investment in Intangibles)							5.42	2.25	676	4.43	2.56	444
Productivity	114,694	350,084	426	83,929	170,830	374	154,435	287,358	860	87,842	163,520	575
ln (Productivity)	10.95	1.14	426	10.42	1.29	374	11.44	0.94	860	10.68	1.17	575
Innovator	0	0	426	0	0	374	98%	14%	860	98%	15%	575
Product	0	0	426	0	0	374	53%	50%	860	46%	50%	575
Process	0	0	426	0	0	374	76%	42%	860	61%	49%	575
Organizational	0	0	426	0	0	374	38%	49%	860	52%	50%	575
Marketing	0	0	426	0	0	374	19%	39%	860	23%	42%	575
Obstacles												
Financial obstacles	64%	48%	426	53%	50%	374	40%	49%	860	30%	46%	575
Knowledge obstacles	50%	50%	426	50%	50%	374	33%	47%	860	33%	47%	575
Market obstacles	61%	49%	426	59%	49%	374	43%	50%	860	31%	46%	575
Institutional STI	23%	42%	426	21%	41%	374	17%	37%	860	9%	29%	575
Context	38%	49%	426	30%	46%	374	25%	43%	860	14%	34%	575
Explanatory Variables												
Age	42.99	19.43	426	33.64	17.60	374	45.91	20.82	860	37.21	24.66	575
Size	100.70	142.96	426	202.51	382.07	374	180.81	256.18	860	422.91	876.18	575
ln (Age)	3.65	0.50	426	3.39	0.50	374	3.71	0.51	860	3.45	0.57	575
ln (Size)	4.09	0.98	426	4.46	1.28	374	4.66	1.00	860	5.09	1.33	575
Exporter	0.44	0.50	426	0.13	0.34	374	0.62	0.49	860	0.22	0.41	575
High education	4.00	4.61	426	8.11	13.27	374	6.49	7.21	860	12.80	15.94	575

Source: Authors' calculations.

4. Results

4.1. Results using the balanced panel

Table 3 shows the results for the joint estimation of equations (2) and (3).[3] While the top panel shows the marginal effects for the determinants of innovation propensity, the bottom panel exhibits the results for innovation investment. In the latter equation, the reported estimates are marginal effects corrected for the probability of being selected into the sample.[4] The first column shows the results for the total amount of investment in innovation activities and the total firms in the relevant sample considered in this paper; that is, considering firms from both industry and service sectors. The following columns disaggregate by sector and type of innovation activities. Column 1 indicates that four of the five barriers to innovation considered affecting innovation propensity, as their coefficient turns out negative and significant from zero. These results suggest that, in general, barriers to innovation reduce from 6.5 percent to 14 percent a firm's probability of engaging in innovative activities in Uruguayan firms. Also, the results of the determinants of (log) innovation expenditure per employee indicate that barriers to innovation related to financing, knowledge, market, and context reduce 47 percent to 89 percent total innovation expenditures. Considering the full (relevant) sample, the same obstacles affect both the propensity and intensity. In this case, institutional factors do not have a significant effect on firms' behavior.

The results shown in columns 2 and 3 are quite interesting. While the coefficients of financial, market, and knowledge obstacles are significant for both sectors, context obstacles only affect the propensity to invest in innovation activities in the services sector. On the other hand, the amount invested appears to be constrained by the context factors in firms in both industry and services sectors. Then, unlike the results for the full sample, when distinguishing between sectors, we find that in the manufacturing industry, context factors are not relevant in the decision of whether to invest in innovation, but they are a consideration in terms of how much to invest. This result may suggest that policy instruments targeted for the services sectors may focus on engaging firms in innovation, while for the industry matching grants or subsidies to increase investment may provide better results (besides other programs aiming to cope with the other significant barriers).

Finally, columns 4 to 5 report the coefficients and marginal effects for the entire sample considering the decision to engage in different innovation activities (tangibles and intangibles). In this case, results should be analyzed with more scrutiny because they differ between types of innovation activity and equation considered (top and bottom panel). Regarding the probability of investing, the financial, market, knowledge, and context obstacles affect tangible investments. On the other hand, only financial, market, and context obstacles reduce the probability of spending in intangible activities. This result is similar to Álvarez and Crespi (2015), who find that financial constraints are particularly important in intangible investments in innovation. Regarding innovation investment for tangibles, the pattern of significant coefficients for innovation barriers is maintained concerning the upper panel. Financial and knowledge barriers also affect investment in this kind of innovation activity. The results in Table 3 confirm the importance of both financial and nonfinancial barriers. With respect to the other covariates, the only size turns significant to explain innovation propensity and intensity.

[3] In this section we show the results for the relevant sample; in Tables A3 to A5 in the Appendix we include the results for the full sample. As can be seen, filtering out the firms not willing to innovate significantly improves the estimations.

[4] This is performed with the *yexpected* option in the *margins* postestimation command in STATA.

Table 3: Effect of Barriers to Innovation on Innovation Propensity and Intensity *(relevant sample)*

ID (probability of investing in innovation IE > 0)	**(1)** **All firms**	**(2)** **Industry**	**(3)** **Services**	**(4)** **Tangibles**	**(5)** **Intangibles**
Financial Obstacles	-0.137***	-0.129***	-0.139***	-0.091***	-0.122***
	(0.019)	(0.024)	(0.029)	(0.021)	(0.020)
Knowledge Obstacles	-0.086***	-0.074***	-0.093***	-0.062***	-0.032
	(0.019)	(0.024)	(0.029)	(0.021)	(0.021)
Market Obstacles	-0.100***	-0.085***	-0.134***	-0.105***	-0.072***
	(0.019)	(0.024)	(0.028)	(0.020)	(0.021)
Institutional Obstacles	0.007	0.029	-0.046	0.009	0.042
	(0.026)	(0.031)	(0.043)	(0.028)	(0.028)
Context Obstacles	-0.065***	-0.040	-0.099***	-0.071***	-0.052**
	(0.022)	(0.026)	(0.036)	(0.024)	(0.024)
ln (Age)	-0.009	-0.024	-0.084	0.022	0.014
	(0.055)	(0.075)	(0.077)	(0.057)	(0.057)
ln (Size)	0.080***	0.137***	0.080***	0.085***	0.065***
	(0.010)	(0.017)	(0.013)	(0.010)	(0.011)
Exporter	0.043	0.028	0.056	-0.006	0.071
	(0.043)	(0.053)	(0.066)	(0.046)	(0.045)
High education	0.001	0.005*	0.000	0.002	0.001
	(0.001)	(0.003)	(0.002)	(0.001)	(0.002)
IE (log of innovation expenditure per employee)					
Financial Obstacles	-0.891***	-0.898***	-0.817***	-0.620***	-0.642***
	(0.142)	(0.181)	(0.232)	(0.148)	(0.128)
Knowledge Obstacles	-0.595***	-0.448**	-0.531**	-0.456***	-0.225*
	(0.145)	(0.183)	(0.231)	(0.151)	(0.131)
Market Obstacles	-0.549***	-0.591***	-0.668***	-0.575***	-0.111
	(0.141)	(0.200)	(0.237)	(0.145)	(0.127)
Institutional Obstacles	0.023	0.160	-0.475	-0.032	0.302*
	(0.197)	(0.254)	(0.333)	(0.205)	(0.177)
Context Obstacles	-0.466***	-0.371*	-0.540*	-0.410**	-0.161
	(0.168)	(0.216)	(0.312)	(0.177)	(0.154)
ln (Age)	0.177	-0.416	-0.316	0.303	0.135
	(0.382)	(0.781)	(0.584)	(0.386)	(0.332)
ln (Size)	0.427***	1.125***	0.342***	0.425***	0.280***
	(0.053)	(0.165)	(0.061)	(0.054)	(0.048)
Exporter	0.204	0.093	0.261	-0.077	0.294
	(0.313)	(0.344)	(0.356)	(0.319)	(0.276)
High education	0.008	0.037	0.001	0.004	0.004
	(0.010)	(0.025)	(0.009)	(0.010)	(0.009)
Observations	2,235	1,286	949	2,235	2,235
Censored obs	800	426	374	1061	1115
Log pseudo likelihood	-4,207	-2,374	-1,716	-3,856	-3,915
LR test of independence	24.62***	22.57***	31.36***	31.90***	11.89***
Year fixed effects	YES	YES	YES	YES	YES
Within mean of independent variables	YES	YES	YES	YES	YES

Source: Authors' calculations.

Notes: ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels, respectively. Robust standard errors in parentheses. In columns 1, 2, and 3 the dependent variables are log expenditure in total innovation activities and a binary indicator that takes the value of 1 if the investment of the firm is greater than 0. Columns 4 and 5 are analogous for the investment in tangibles and intangibles activities respectively.

Table 4 illustrates the results for the estimation of the knowledge production function. We estimate the models for the general definition of innovator and then for each type of innovation (technological and non-technological innovators). For the regressions considering the full sample, we find that the predicted innovation investment is significant to explain innovation results. However, in the regressions by sector the coefficient becomes non-significant. Also, the likelihood ratio test for the significance of the individual component of the variance (rho) is significant for all the specifications, indicating that the random effects specification is suitable for the data, as opposed to the pooled estimator. Similar to the results for innovation intensity, we find that four obstacles (cost, market, knowledge, and context) reduce the probability of introducing successful innovations (Column 1). The presence of obstacles to innovation translates to a reduction of 6.5 percent to 12 percent in the firms' innovation outcomes. When considering each type of innovation separately, the results differ. While both technological and non-technological innovations are constrained by financial and market obstacles, product and process innovations are also affected by knowledge obstacles, whereas organizational and marketing innovations are affected by context obstacles. This last result is in line with Schubert (2010), who finds that the market environment affects organizational innovation.

Columns 4 to 6 and 7 to 9 show the results individually for firms in the industry and services sectors respectively. The probability of introducing new innovations for the firm in the manufacturing sector is affected by the financial, market, knowledge, and context obstacles. When considering technological innovation this last coefficient becomes non-significant. Surprisingly, non-technological innovations do not appear to be constrained by any of the obstacles considered here. Finally, columns 7 to 9 report the marginal effects for the firms in the services sector. Technological innovators face the same obstacles as in the industry sector, but the market coefficient was greater in the service sector, while non-technological innovators face financial and market constraints. This last result is interesting as non-technological innovations in the services sectors are not constrained by "soft" barriers such as knowledge but by market and financial obstacles. Regarding the rest of the covariates, the number of employees is significant to explain the introduction of innovations throughout all the specifications. The proportion of highly skilled workers enhances innovation outcomes for firms in the industry sector, while firms more export-oriented are more likely to introduce innovations in the services sector.

Table 4: Effect of Barriers to Innovation on Innovation Outcomes *(relevant sample)*

	All Firms			Industry			Services		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Innovator	Technological Innovator	Non-Technological Innovator	Innovator	Technological Innovator	Non-Technological Innovator	Innovator	Technological Innovator	Non-Technological Innovator
IE predicted	0.065**	0.087***	0.003	0.010	0.002	0.039	0.032	0.005	0.047
	(0.032)	(0.033)	(0.033)	(0.044)	(0.045)	(0.045)	(0.056)	(0.058)	(0.057)
Financial Obstacles	-0.092***	-0.080***	-0.072***	-0.114***	-0.115***	-0.034	-0.103***	-0.097***	-0.108***
	(0.021)	(0.022)	(0.022)	(0.027)	(0.028)	(0.029)	(0.033)	(0.035)	(0.036)
Knowledge Obstacles	-0.067***	-0.061***	0.002	-0.070***	-0.073***	0.005	-0.086***	-0.078**	0.001
	(0.021)	(0.022)	(0.023)	(0.027)	(0.028)	(0.029)	(0.032)	(0.035)	(0.035)
Market Obstacles	-0.123***	-0.099***	-0.044**	-0.090***	-0.081***	-0.028	-0.181***	-0.138***	-0.072**
	(0.019)	(0.020)	(0.021)	(0.025)	(0.026)	(0.027)	(0.027)	(0.030)	(0.032)
Institutional Obstacles	0.007	0.026	0.015	0.021	0.026	0.047	-0.024	0.008	-0.041
	(0.025)	(0.027)	(0.028)	(0.031)	(0.033)	(0.034)	(0.042)	(0.046)	(0.049)
Context Obstacles	-0.055**	-0.029	-0.051**	-0.056**	-0.025	-0.041	-0.075**	-0.082**	-0.054
	(0.022)	(0.024)	(0.025)	(0.028)	(0.030)	(0.031)	(0.037)	(0.041)	(0.043)
Exporter	0.056	0.071*	0.020	0.005	0.007	-0.054	0.126**	0.159***	0.121**
	(0.037)	(0.038)	(0.040)	(0.049)	(0.051)	(0.052)	(0.055)	(0.057)	(0.061)
ln (size)	0.070***	0.060***	0.050***	0.143***	0.143***	0.056***	0.053***	0.037**	0.053***
	(0.013)	(0.013)	(0.012)	(0.021)	(0.022)	(0.021)	(0.018)	(0.019)	(0.018)
High education	0.002	0.000	0.003**	0.007**	0.003	0.008***	0.001	-0.001	0.002
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)	(0.001)	(0.002)	(0.002)
Observations	2,235	2,235	2,235	1,286	1,286	1,286	949	949	949
LR rho=0	116.5***	139.00***	32.30***	33.96***	52.42***	9.191***	54.82***	48.60***	21.51***
Year fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Within mean of independent variables	YES	YES	YES	YES	YES	YES	YES	YES	YES

Source: Authors' calculations. *Notes:* ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels, respectively. In each column the dependent variable is a dummy that takes the value of 1 if the firm successfully introduced innovation and 0 otherwise.

Table 5 shows the result of the labor productivity equation. Columns 1 to 3 show the results for the full (relevant) sample, where we find positive significant signs for the knowledge and market coefficients. We argue that these results may be caused by the large dispersion of the dependent variable, as shown in the previous section. In Columns 4 to 6 we show the results using a winsorized sample removing observations below the 5th and above the 95th percentile of the distributions. We find that innovation propensity had a positive but not significant impact on labor productivity. Also, there is no evidence that obstacles affect our dependent variable. These results are similar to Mohan, Stroble, and Watson (2017) for Caribbean firms.

Table 5: Effects of Barriers to Innovation on Labor Productivity

	Full Sample			Trimmed Sample		
	(1)	(2)	(3)	(4)	(5)	(6)
	All firms	Industry	Services	All firms	Industry	Services
IO predicted	0.939**	0.711	0.750	0.604	0.646	0.145
	(0.430)	(0.612)	(0.620)	(0.483)	(0.729)	(0.658)
Financial Obstacles	0.067	0.019	0.074	0.033	0.023	0.002
	(0.056)	(0.079)	(0.082)	(0.063)	(0.095)	(0.087)
Knowledge Obstacles	0.111**	0.110*	0.069	0.082*	0.110	0.013
	(0.045)	(0.062)	(0.066)	(0.050)	(0.074)	(0.069)
Market Obstacles	0.115*	0.096	0.080	0.074	0.080	0.012
	(0.061)	(0.086)	(0.089)	(0.069)	(0.102)	(0.095)
Institutional Obstacles	0.038	0.063	-0.025	0.023	0.063	-0.069
	(0.034)	(0.041)	(0.059)	(0.036)	(0.045)	(0.061)
Context Obstacles	0.031	-0.002	0.058	0.011	-0.014	0.040
	(0.042)	(0.056)	(0.066)	(0.046)	(0.065)	(0.069)
ln (Size)	-0.555***	-0.461***	-0.628***	-0.466***	-0.390***	-0.533***
	(0.049)	(0.073)	(0.068)	(0.055)	(0.083)	(0.074)
Constant				12.005***	11.877***	12.381***
				(0.289)	(0.429)	(0.404)
Observations	2,235	1,286	949	1,912	1,077	835
R-squared	0.334	0.294	0.395	0.325	0.284	0.394
Year fixed effects	YES	YES	YES	YES	YES	YES

Source: Authors' calculations.
Notes: ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels, respectively. In all columns the dependent variable is the natural logarithm of labor productivity.

So far, we have analyzed the results of the estimations for each stage of the model separately, which can become cumbersome as the tables include several columns analyzing different sets of firms and/or innovation activities. In order to ease the interpretation of the results, we include a table with the summary of findings by estimation procedure and barrier. In summary, Table 6 helps us to draw the following conclusions relating to the relevance of each barrier in the innovation process:

- Financial obstacles appear as the most important factors hampering innovation because it is significant across almost all estimations.
- Knowledge and market obstacles affect innovation propensity to a similar extent. However, market obstacles appear more significant in the case of innovation outcomes.
- Institutional obstacles are non-significant.
- Context obstacles are more important constraints to engagement and investment than explaining failure in achieving innovation outputs.

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Table 6: Summary of Findings by Obstacle and Estimated Equation

	Innovation Propensity	Innovation Intensity	Innovation Outcomes	Labor Productivity
Financial	Significant throughout all the specifications	Significant throughout all the specifications	Significant throughout all the specifications except for industry non-technological innovation	Non-significant
Knowledge	Significant throughout all the specifications except for intangibles	Significant throughout all the specifications	Significant in all cases for general and technological innovation; non-significant in any case for non-technological innovation	Non-significant
Market	Significant throughout all the specifications	Significant throughout all the specifications except for intangibles	Significant throughout all the specifications except for industry non-technological innovation	Non-significant
Institutional	Non-significant	Non-significant	Non-significant	Non-significant
Context	Significant throughout all the specifications except for industry firms	Significant throughout all the specifications except for intangibles	All firms: significant for general and non-technological innovation; industry: significant for general innovation; services: significant for general and technological innovation	Non-significant

Source: Authors' calculations.
Note: Coefficient significant at the 1 percent, 5 percent, and 10 percent levels.

4.2. Robustness check: results using the unbalanced panel

In this section, we include the econometric analysis for the unbalanced panel as a robustness test. The tables below show no to little variation with respect to the results found using the balanced panel.

Table 7: Effect of Barriers to Innovation on Innovation Propensity and Intensity. Unbalanced panel. *(relevant sample)*

ID (probability of investing in innovation IE > 0)	(1) All firms	(2) Industry	(3) Services	(4) Tangibles	(5) Intangibles
Financial Obstacles	-0.137***	-0.129***	-0.139***	-0.091***	-0.122***
	(0.019)	(0.024)	(0.029)	(0.021)	(0.020)
Knowledge Obstacles	-0.086***	-0.074***	-0.093***	-0.062***	-0.032
	(0.019)	(0.024)	(0.029)	(0.021)	(0.021)
Market Obstacles	-0.100***	-0.085***	-0.134***	-0.105***	-0.072***
	(0.019)	(0.024)	(0.028)	(0.020)	(0.021)
Institutional Obstacles	0.007	0.029	-0.046	0.009	0.042
	(0.026)	(0.031)	(0.043)	(0.028)	(0.028)
Context Obstacles	-0.065***	-0.040	-0.099***	-0.071***	-0.052**
	(0.022)	(0.026)	(0.036)	(0.024)	(0.024)
ln (Age)	-0.009	-0.024	-0.084	0.022	0.014
	(0.055)	(0.075)	(0.077)	(0.057)	(0.057)
ln (Size)	0.043	0.028	0.056	-0.006	0.071
	(0.043)	(0.053)	(0.066)	(0.046)	(0.045)
Exporter	0.001	0.005*	0.000	0.002	0.001
	(0.001)	(0.003)	(0.002)	(0.001)	(0.002)
High education	-0.137***	-0.129***	-0.139***	-0.091***	-0.122***
	(0.019)	(0.024)	(0.029)	(0.021)	(0.020)
IE (log of innovation expenditure per employee)					
Financial Obstacles	-0.945***	-0.985***	-0.836***	-0.672***	-0.675***
	(0.138)	(0.176)	(0.225)	(0.143)	(0.124)
Knowledge Obstacles	-0.568***	-0.408**	-0.518**	-0.432***	-0.232*
	(0.142)	(0.181)	(0.225)	(0.147)	(0.128)
Market Obstacles	-0.589***	-0.660***	-0.670***	-0.623***	-0.140
	(0.137)	(0.194)	(0.229)	(0.141)	(0.123)
Institutional Obstacles	0.064	0.205	-0.421	0.038	0.308
	(0.192)	(0.249)	(0.325)	(0.198)	(0.190)
Context Obstacles	-0.409**	-0.347*	-0.454	-0.370**	-0.124
	(0.164)	(0.208)	(0.301)	(0.171)	(0.148)
ln (Age)	0.255	-0.296	-0.194	0.401	0.203
	(0.369)	(0.704)	(0.565)	(0.371)	(0.319)
ln (Size)	0.469***	1.227***	0.346***	0.462***	0.306***
	(0.052)	(0.154)	(0.059)	(0.053)	(0.046)
Exporter	0.357	0.187	0.439	0.086	0.358
	(0.305)	(0.343)	(0.355)	(0.309)	(0.267)
High education	0.004	0.019	-0.001	0.000	0.002
	(0.010)	(0.018)	(0.009)	(0.010)	(0.009)
Observations	2,337	1,342	995	2,337	2,337
Censored obs	868	465	403	1138	1190
Log pseudo likelihood	-4,342	-2,441	-1,787	-3,856	-4,033
LR test of independence	26.74***	21.65***	29.60***	32.84***	13.51***
Year fixed effects	YES	YES	YES	YES	YES
Within mean of independent variables	YES	YES	YES	YES	YES

Source: Authors' calculations. *Notes:* ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels, respectively. Robust standard errors in parentheses. In columns 1, 2, and 3 the dependent variables are log expenditure in total innovation activities and a binary indicator that takes the value of 1 if the investment of the firm is greater than 0. Columns 4 and 5 are analogous for the investment in tangibles and intangibles activities respectively.

Table 8: Effect of Barriers to Innovation on Innovation Outcomes. Balanced Sample *(relevant sample)*

	All Firms			Industry			Services		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Innovator	Technological Innovator	Non-Technological Innovator	Innovator	Technological Innovator	Non-Technological Innovator	Innovator	Technological Innovator	Non-Technological Innovator
IE predicted	0.060*	0.089***	-0.008	-0.017	-0.001	0.031	0.022	0.002	-0.066
	(0.034)	(0.035)	(0.034)	(0.046)	(0.048)	(0.047)	(0.058)	(0.060)	(0.059)
Financial Obstacles	-0.092***	-0.079***	-0.071***	-0.124***	-0.122***	-0.036	-0.102***	-0.100***	-0.108***
	(0.022)	(0.023)	(0.023)	(0.028)	(0.029)	(0.030)	(0.034)	(0.036)	(0.037)
Knowledge Obstacles	-0.066***	-0.059***	-0.003	-0.070***	-0.072***	0.001	-0.083***	-0.071**	-0.007
	(0.020)	(0.021)	(0.022)	(0.026)	(0.028)	(0.029)	(0.032)	(0.034)	(0.034)
Market Obstacles	-0.123***	-0.096***	-0.051**	-0.097***	-0.086***	-0.037	-0.171***	-0.127***	-0.076**
	(0.018)	(0.019)	(0.020)	(0.024)	(0.025)	(0.026)	(0.028)	(0.030)	(0.031)
Institutional Obstacles	0.011	0.030	0.017	0.023	0.030	0.040	-0.015	0.016	-0.025
	(0.025)	(0.026)	(0.027)	(0.031)	(0.033)	(0.033)	(0.041)	(0.045)	(0.046)
Context Obstacles	-0.046**	-0.020	-0.047*	-0.051*	-0.020	-0.036	-0.061*	-0.067*	-0.047
	(0.022)	(0.023)	(0.024)	(0.027)	(0.029)	(0.030)	(0.037)	(0.040)	(0.042)
Exporter	0.056	0.066*	0.028	0.005	0.007	-0.056	0.132**	0.158***	0.137**
	(0.038)	(0.039)	(0.041)	(0.051)	(0.053)	(0.054)	(0.058)	(0.060)	(0.062)
ln (size)	0.081***	0.068***	0.057***	0.160***	0.158***	0.070***	0.055***	0.035*	0.058***
	(0.012)	(0.013)	(0.012)	(0.020)	(0.021)	(0.020)	(0.017)	(0.018)	(0.017)
High education	-0.000	-0.000	0.000	-0.000	-0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	2,337	2,337	2,337	1,342	1,342	1,342	995	995	995
LR rho=0	120.2***	142.70***	34.45***	38.70***	56.54***	9.04***	52.38***	45.80***	24.60***
Year fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Within mean of independent variables	YES	YES	YES	YES	YES	YES	YES	YES	YES

Source: Authors' calculations. *Notes:* ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels, respectively. In each column the dependent variable is a dummy that takes the value of 1 if the firm successfully introduced innovation and 0 otherwise.

Table 5: Effects of Barriers to Innovation on Labor Productivity. Unbalanced Sample. *(relevant sample)*

	(1)	(2)	(3)
	All firms	Industry	Services
IO predicted	0.765*	0.480	0.746
	(0.438)	(0.603)	(0.647)
Financial Obstacles	0.050	-0.008	0.080
	(0.057)	(0.079)	(0.086)
Knowledge Obstacles	0.090	0.083	0.066
	(0.094)	(0.059)	(0.066)
Market Obstacles	0.100	0.081	0.079
	(0.063)	(0.085)	(0.094)
Institutional Obstacles	0.032	0.056	-0.029
	(0.034)	(0.041)	(0.058)
Context Obstacles	0.019	-0.016	0.056
	(0.039)	(0.051)	(0.063)
ln (Size)	-0.525***	-0.425***	-0.626***
	(0.050)	(0.070)	(0.074)
Constant	12.409***	12.517***	12.146***
	(0.330)	(0.354)	(0.229)
Observations	2,337	1,342	995
R-squared	0.353	0.294	0.395
Year fixed effects	YES	YES	YES

Source: Authors' calculations.
Notes: ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels, respectively. In all columns the dependent variable is the natural logarithm of labor productivity.

5. Discussion

In this section, we analyze the implications of the results previously found.

In terms of the goals of our paper detailed in the introduction, we can argue the following. We find that obstacles to innovation are important factors reducing the innovation propensity, innovation intensity, and innovation outcomes. On the contrary, we do not find that obstacles to innovation reduce labor productivity. We believe that the fact that we do not find that obstacles affect productivity is conditioned by the large dispersion of the variable that we cannot improve even when winsorizing the sample used in the regressions. Also we believe that because of this defect of our data, labor productivity is not the best variable to use in this case. Total factor productivity or value-added per employee (the proxy variable for productivity Crepon, Duguet, and Mairesse, 1998) arise as more suitable measures of productivity and should be tested in future research.

Our estimations show that barriers to innovation impact the industry and services sectors in a similar way, while the effects found in tangible investments are larger than those in intangible ones. While we find that context obstacles are important factors hindering innovation propensity and innovation outcomes, we do not find evidence that they affect innovation intensity. This is caused by the fact that context obstacles reflect macroeconomic environment and infrastructure and thus affect the part of the innovation process most sensitive to uncertainty (the decision to innovate and innovation outcomes). On the other hand, we do not find that institutional obstacles affect any of the variables analyzed. The fact that institutional factors do not affect the innovation process should be taken as good news by policymakers. This result is in line with statements from policy actors in Latin America praising Uruguayan STI institutions (Angelelli et al., 2017).

What can be learned from these results and how can policymakers in Uruguay mitigate the effects of obstacles to innovation? Regarding financial barriers, these issues have been addressed in the last decade by ANII through a set of programs promoting innovation activities in the productive sector. An impact evaluation by Bukstein et al. (2017) shows evidence of a crowding-in effect for beneficiaries of ANII's programs, as treated firms spend two to three times more in R&D and three to four times more in innovation activities than the control group. However, the scope of ANII is still small at the national level, with less than 1 percent of national firms engaging in this type of program. Therefore, the main challenge for policy actions in this regard is to increase the reach of instruments to foster innovation with focus in intangible investments. Also, promoting cooperation between firms might help reduce the costs of innovation projects as shown by Antonioli, Marzucchi, and Savona (2017). Concerning the market structure–related obstacles, this is the most challenging obstacle to overcome as its reduced size is an intrinsic characteristic of the Uruguayan market. We, therefore, infer that the lack of demand is decisive for firms to give up innovation projects. In this sense, the policy actions should focus on insertion of firms into global value chains or help in placing their products in international markets. With respect to knowledge-related obstacles, it is necessary to foster the link between academia and industry, for example, funding the training of highly qualified professionals and aiding their insertion in the productive sectors.

Finally, results indicate that policymakers should keep in mind that macroeconomic instability and uncertainty not only harm economic performance through higher unemployment but also via preventing firms from engaging in innovation activities. In this regard, the results suggest that in times of economic downturn, policy instruments targeted for the services sectors may focus on engaging firms in innovation, while for the industry matching grants or subsidies to increase investment may provide better results (besides other programs aiming to cope with other significant barriers).

6. Concluding Remarks

This paper presents evidence that barriers to innovation have a substantial effect on innovation propensity, intensity, and outcomes. On the other hand, we do not find evidence that barriers affect labor productivity. In terms of the objectives of the study, we do not find evidence that institutional obstacles are important factors hampering innovation; however, it is important to note that the rest of the financial and nonfinancial barriers considered are significant. The results show that obstacles affect the innovative behavior of firms in the industry and services sectors similarly. We confirm that different barriers hamper investment in tangible and intangible activities.

The presence of obstacles to innovation translates to a reduction of 47 percent to 89 percent in the firms' innovation efforts; also, it translates to a reduction of 6.5 percent to 14 percent in the firms' innovation propensity. Financial, market, knowledge, and context obstacles are the most important factors reducing the probability to engage in innovation activities and the amount invested. On the other hand, the empirical analysis indicates that barriers related to the systemic failure of STI institutions are not significant. While expenditure on equipment is affected mainly by the four obstacles mentioned above, investment in R&D and other intangible activities are mostly constrained by market and financial barriers. Regarding innovation outcomes, we find that financial and market factors are the most important, whereas the role of context and knowledge barriers varies between types of innovation. Finally, we do not find effects of obstacles to innovation on labor productivity.

The evidence presented throughout this paper should serve as an input for future policymaking. From a national system of innovation perspective, it is crucial for policymakers to understand which obstacles slow down the firms' innovation process (Chaminade and Edquist, 2006). As Galia, Mancini, and Morandi (2012) point out, different types of obstacles and innovator profiles demand different interventions. Our results suggest that a systemic approach to overcome several barriers is needed. In order to increase engagement in innovation activities and expenditure intensity, a mixture of instruments focusing in financial, market, and knowledge is needed (innovation widening) along with expanding the reach of innovative activities and increasing innovation outcomes (innovation deepening). Regarding the economic sectors, the results suggest that policies can be applied broadly.

Future research topics include studying the complementarities between the barriers and other questions such as the cooperation strategy of the firms in order to cope with innovation obstacles. Also, new studies including productivity should aim to use new measures of this important variable, such as value-added per employee or total factor productivity.

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Appendix

Table A1. Sectoral Composition of the Firms in the Relevant Sample

Sector	N	Frequency (%)
Manufacture of food products	389	17.46
Growing of non-perennial crops	70	3.13
Growing of perennial crops	4	0.18
Plant propagation	57	2.59
Animal production	71	3.17
Mixed farming	49	2.23
Support activities to agriculture and post-harvest crop activities	39	1.74
Hunting, trapping, and related service activities	26	1.16
Printing and reproduction of recorded media	53	2.37
Manufacture of chemicals and chemical products	116	5.18
Silviculture and other forestry activities	96	4.29
Logging	66	2.95
Gathering of non-wood forest products	49	2.19
Support services to forestry	19	0.85
Manufacture of fabricated metal products, except machinery and equipment	40	1.79
Manufacture of computer, electronic, and optical products	7	0.31
Manufacture of electrical equipment	39	1.74
Manufacture of machinery and equipment not elsewhere classified	4	0.18
Manufacture of motor vehicles, trailers, and semi-trailers	25	1.16
Manufacture of other transport equipment	7	0.31
Fishing	20	0.89
Aquaculture	26	1.16
Repair and installation of machinery and equipment	12	0.54
Electricity, gas, steam, and air-conditioning supply	6	0.27
Water collection, treatment, and supply	3	0.13
Land transport and transport via pipelines	127	5.67
Water transport	18	0.8
Mining of hard coal	9	0.4
Mining of lignite	104	4.64
Postal and courier activities	10	0.45
Accommodation	62	2.77
Food and beverage service activities	22	0.98
Publishing activities	34	1.52
Motion picture, video and television program production, sound recording, and music publishing activities	3	0.13
Extraction of crude petroleum	48	2.14
Extraction of natural gas	30	1.34
Legal and accounting activities	8	0.36
Activities of head offices; management consultancy activities	13	0.58
Mining of iron ores	4	0.18
Mining of non-ferrous metal ores	6	0.27
Advertising and market research	34	1.52
Rental and leasing activities	12	0.54
Employment activities	35	1.56
Travel agency, tour operator, reservation service, and related activities	36	1.61
Security and investigation activities	55	2.46
Quarrying of stone, sand, and clay	25	1.12
Office administrative, office support, and other business support activities	27	1.21
Human health activities	220	9.78
Total	2,235	100

Table A2: Mean Differences between Public and Non-Public Companies in Innovation Investment and Size

	Non-Public	Public	Difference
Total investment in innovation activities (current USD)	434,413	14,278,844	-13,844,431***
Investment in R&D	24,202	989,629	-965,427***
Investment in equipment	381,460	11,267,171	-10,885,711***
Investment in other innovation activities	28,751	2,022,043	-1,993,293***
Size	231	2,100	-1,869***

Table A3. Effect of Barriers to Innovation on Innovation Propensity and Intensity (Full Sample)

AI (probability of investing in innovation IE > 0)	**(1) All**	**(2) Industry**	**(3) Services**	**(4) Tangibles**	**(5) Intangibles**
Financial Obstacles	-0.017	-0.017	-0.012	0.007	-0.030
	(0.021)	(0.027)	(0.033)	(0.021)	(0.021)
Knowledge Obstacles	0.029	0.016	0.050	0.032	0.054***
	(0.021)	(0.028)	(0.032)	(0.021)	(0.021)
Market Obstacles	0.041**	0.039	0.009	0.005	0.031
	(0.020)	(0.027)	(0.031)	(0.020)	(0.020)
Institutional Obstacles	0.011	0.052	-0.067	0.014	0.044
	(0.029)	(0.036)	(0.049)	(0.029)	(0.028)
Context Obstacles	-0.026	0.000	-0.072*	-0.038	-0.021
	(0.025)	(0.030)	(0.041)	(0.025)	(0.024)
ln (Age)	-0.009	0.051	-0.129*	0.016	0.016
	(0.055)	(0.077)	(0.075)	(0.054)	(0.053)
ln (Size)	0.102***	0.150***	0.100***	0.097***	0.083***
	(0.010)	(0.017)	(0.012)	(0.010)	(0.010)
Exporter	0.023	0.025	0.030	-0.014	0.047
	(0.042)	(0.054)	(0.062)	(0.042)	(0.041)
High education	0.001	0.006**	-0.000	0.001	0.001
	(0.001)	(0.003)	(0.002)	(0.001)	(0.001)
IE (log of innovation expenditure per employee)					
Financial Obstacles	-0.110	-0.156	-0.052	0.013	-0.182
	(0.148)	(0.195)	(0.227)	(0.144)	(0.121)
Knowledge Obstacles	0.161	0.124	0.336	0.155	0.217*
	(0.150)	(0.194)	(0.226)	(0.146)	(0.121)
Market Obstacles	0.333**	0.233	0.154	0.102	0.353***
	(0.145)	(0.208)	(0.243)	(0.141)	(0.118)
Institutional Obstacles	0.057	0.325	-0.561*	0.019	0.296*
	(0.205)	(0.282)	(0.321)	(0.199)	(0.165)
Context Obstacles	-0.193	-0.089	-0.359	-0.201	-0.021
	(0.176)	(0.233)	(0.296)	(0.172)	(0.144)
ln (Age)	0.121	0.164	-0.602	0.233	0.116
	(0.371)	(0.723)	(0.567)	(0.356)	(0.297)
ln (Size)	0.549***	1.236***	0.435***	0.501***	0.356***
	(0.054)	(0.173)	(0.061)	(0.053)	(0.044)
Exporter	0.089	0.103	0.116	-0.124	0.184
	(0.297)	(0.360)	(0.347)	(0.287)	(0.242)
High education	0.006	0.041**	-0.001	0.004	0.002
	(0.009)	(0.019)	(0.009)	(0.009)	(0.008)
Observations	2,708	1,512	1,196	2,708	2,708
Number of obs	2708	1512	1196	2708	2708
Censored obs	1273	652	621	1534	1588
Log pseudo likelihood	-4682	-2625	-1943	-4191	-4217
LR test of independence	37.73	30.15	51.22	36.50	17.18
Year fixed effects	YES	YES	YES	YES	YES
Within mean of independent variables	YES	YES	YES	YES	YES

Note: ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels respectively. Robust standard errors in parentheses. In columns 1, 2, and 3 the dependent variables are log expenditure in total innovation activities and a binary indicator that takes the value of 1 if the investment of the firm is greater than 0. Columns 4 and 5 are analogous for the investment in tangibles and intangibles activities respectively.

Table A4. Effect of Barriers to Innovation on Innovation Outcomes (Full Sample)

	All			Industry			Services		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Innovator	Technological Innovator	Non-Technological Innovator	Innovator	Technological Innovator	Non-Technological Innovator	Innovator	Technological Innovator	Non-Technological Innovator
IE predicted	0.102***	0.111***	0.024	0.024	0.028	0.044	0.067	0.039	-0.009
	(0.031)	(0.031)	(0.028)	(0.043)	(0.044)	(0.039)	(0.053)	(0.052)	(0.049)
Financial Obstacles	0.032	0.024	-0.005	0.007	-0.008	0.018	0.026	0.009	-0.025
	(0.022)	(0.022)	(0.020)	(0.029)	(0.029)	(0.027)	(0.035)	(0.035)	(0.033)
Knowledge Obstacles	0.049**	0.035	0.060***	0.030	0.017	0.043	0.056*	0.035	0.084***
	(0.022)	(0.022)	(0.020)	(0.029)	(0.029)	(0.027)	(0.034)	(0.034)	(0.031)
Market Obstacles	0.003	0.008	0.020	0.022	0.019	0.023	-0.034	-0.018	0.011
	(0.020)	(0.020)	(0.019)	(0.027)	(0.027)	(0.024)	(0.031)	(0.031)	(0.029)
Institutional Obstacles	0.013	0.031	0.020	0.031	0.035	0.053*	-0.033	0.006	-0.039
	(0.028)	(0.028)	(0.026)	(0.035)	(0.035)	(0.031)	(0.048)	(0.047)	(0.045)
Context Obstacles	-0.004	0.015	-0.025	-0.005	0.023	-0.019	-0.040	-0.047	-0.026
	(0.025)	(0.025)	(0.023)	(0.031)	(0.031)	(0.029)	(0.042)	(0.042)	(0.040)
Exporter	0.020	0.038	0.004	-0.020	-0.013	-0.056	0.068	0.101**	0.077
	(0.035)	(0.034)	(0.034)	(0.047)	(0.047)	(0.046)	(0.052)	(0.051)	(0.050)
ln (Size)	0.092***	0.080***	0.059***	0.156***	0.154***	0.065***	0.077***	0.058***	0.060***
	(0.013)	(0.013)	(0.011)	(0.022)	(0.023)	(0.019)	(0.017)	(0.017)	(0.016)
High education	0.001	-0.000	0.002**	0.007**	0.004	0.007***	-0.000	-0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)
Observations	2.708	2.708	2.708	1.512	1.512	1.512	1.196	1.196	1.196
LR rho=0	167.6***	186.4***	48.42***	75.39***	88.64***	12.36***	62.06***	59.38***	35.33***
Year fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Within mean of independent variables	YES	YES	YES	YES	YES	YES	YES	YES	YES

Note: ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels respectively. In each column the dependent variable is a dummy that takes the value of 1 if the firm successfully introduced innovation and 0 otherwise.

Table A4. Effect of Barriers to Innovation on Labor Productivity (Full Sample)

	(1) All Firms	(2) Industry	(3) Services
IO predicted	1.308***	1.163*	1.155**
	(0.435)	(0.646)	(0.586)
Financial Obstacles	0.119**	0.092	0.118
	(0.057)	(0.083)	(0.078)
Knowledge Obstacles	0.158***	0.165**	0.130**
	(0.046)	(0.067)	(0.064)
Market Obstacles	0.168***	0.151	0.150*
	(0.063)	(0.092)	(0.086)
Institutional Obstacles	0.020	0.060	-0.063
	(0.037)	(0.047)	(0.060)
Context Obstacles	0.061	0.037	0.081
	(0.044)	(0.061)	(0.066)
ln (Size)	-0.596***	-0.470***	-0.680***
	(0.047)	(0.075)	(0.060)
Constant	12.228***	12.027***	12.440***
	(0.259)	(0.390)	(0.344)
Observations	2,708	1,512	1,196
R-squared	0.309	0.248	0.396
Year fixed effects	YES	YES	YES

Note: ***, **, and * indicate significance at the 1 percent, 5 percent, and 10 percent levels respectively. In all columns the dependent variable is the natural logarithm of labor productivity.

Input, Output, and Behavioral Additionality of Innovation Subsidies**

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Abstract: Using a Conditional Difference in Difference procedure and data for Colombia, we determine if firms that receive subsidies to innovation in the period 2010-2016 present additionality on input, output, and behavioral innovation variables. We found that there are differences among the additionalities of small and medium firms (SMEs) and big firms, and the existence of a crowding-out effect for internal R&D expenditures in SMEs. At the same time, we found additionality on R&D employment for all types of firms and the presence of experience effects introduced by subsidies, especially for SMEs. These effects are related to positive additionalities. At the same time, we cannot find additionality effects on patents and trademarks. However, we found negative additionality on sales of big companies that we relate with the way we measure this variable.

Keywords: Parametric matching**,** R&D&i, difference in differences, DANE, abandonment, patents, trademarks, innovation impediments

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1. Introduction

Innovation economics has been focused on business innovation as an economic growth driver. According to literature, the way innovation and regional and national economic growth are connected is through the firms productivity increase (Färe, Grosskopf, Fukuyama, & Margaritis, 2011; Nelson, 1959), and therefore, one may think that regions and countries all around the world seek to maximize their R&D&i (Research, Development and Innovation) investments as a way to improve their productivity. However, it is possible to find in those countries substantial differences in the investment levels, especially in underdeveloped countries whose investments in R&D&i are less than low.

Some of the causes found in literature as an explanation of those differences between developed and underdeveloped economies are related to the existence of market failures. In the case of R&D&i ventures, it seems to be more frequent and stronger than other types of ventures, like fixed capital investments (Hall & Lerner, 2009). In the first place, firms cannot privately appropriate all the benefits of their investments, given that knowledge generated inside the firm becomes a public good; that is, knowledge is a non-rival and non-exclusive asset. Therefore, even when there is a social expectation for more R&D&i private investment, firms face a disincentive to finance a public good privately.

Secondly, information asymmetries in the case of R&D&i projects are strong; this market failure causes future expectations about the results of innovation projects to be uncertain, both for the company and for its potential external funders (Hall & Lerner, 2009). The latter means that R&D ventures are risky, and therefore, external financial costs are higher for these type of projects, then, companies investment level is lower than the socially desired one, since the private and social returns of this type of investments diverge (Arrow, 1972).

The fact that knowledge generated by firms on R&D&i projects becomes a public good is related to what is known in the literature as spillover effects. These effects, generally positive, can benefit firms that carry out R&D&i expenditures, their rivals, and in general, the market in which these companies are located (Jaffe, Trajtenberg, & Henderson, 1993). In such a way, society wants private companies to invest in R&D&i projects to generate such spillover effects. However, as already anticipated, private firms will not be willing to finance the entirety of these investments. In this sense, public investment in R&D&i plays a preponderant role, since it is called to replace the lack of private investment funds as a way to generate the spillover effects sought by society (G. Crespi, Garone, Maffioli, & Melendez, 2015).

In order to encourage firms to invest in R&D&i, governments promote some policies focused on increasing the quantity and quality of projects; two of these incentives are tax deductions and business subsidies for carrying out R&D&i ventures. However, given that governments must prioritize their expenditures towards programs where more significant impacts are expected, the evaluation of the effects caused by such aids is fundamental, especially in underdeveloped countries, where budget deficits are substantial.

However, assessing the effect that public R&D&i policies have on private companies and the society is not an easy task, especially for policymakers, which most of the time have data restrictions related to the intangibility of the results of this type of ventures (David, Hall, & Toole, 2000). That is, in some cases, policymakers cannot even make measurements that allow them to understand if subsidies given to the private sector have generated some effect on firms and society.

In the last 30 years, innovation researchers have tried to measure spillover effects generated by public policies, especially in the case of business subsidies for carrying out R&D&i ventures. These effects are named additionality effects, and are generally grouped in three

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different types of effects. First, input additionality, e.g. increase in private R&D expenditure, employment increase, etc.; secondly, output additionality, e.g. increase of innovative products and services revenues, propensity to register patents, etc.; and third, behavioral additionality e.g. propensity to innovate, effects on the number of abandoned or delayed innovation projects, etc. However, literature about subsidy effects has been largely focused on determining the effects of input additionality, but the other types of additionalities have been left aside, especially those related to the firm's behavior.

It is essential to point out that when it comes to assess the effects of innovation subsidies, the temporality of the study is not a trivial matter, because additionality can occur in the short term, as it is the case of input additionality; e.g., a firm spends more on R&D as soon as it receives a public subsidy for innovation. However, it can also occur in the long term, as it is the case of output additionality; e.g., the company will achieve sales of innovative products once they carry out an innovation project and manage to convince the market of the advantages of their products and services. However, the last happens in the middle and long term, so it is essential to focus not only on the short but also in the long term (Zúñiga-Vicente, Alonso-Borrego, Forcadell, & Galán, 2014).

On the other hand, even though in the last 30 years, a genuine interest has been generated in the evaluation of R&D&i policies through subsidies, the vast majority of these evaluations are carried out in developed countries. In the case of Latin American and developing countries, there is not a large number of studies, due in part to the fact that not all countries have the microdata needed to carry them out (innovation surveys based on the Oslo Manual). Similarly, in the vast majority of literature, studies focus on input additionality, specifically in R&D expenditure, trying to determine if there is a crowding-out effect between public subsidies and private spending on R&D&i (Zúñiga-Vicente et al., 2014) but letting behavioral and output additionality aside.

Within Latin American countries, Colombia stands out for its lack of investment in R&D&i; its total expenditure for 2017 raises to 0.24% of GDP, of which only 49% was financed with private resources. This shows there is a problem regarding the interest of private firms in carrying out this type of projects; however, it also shows that public resources, which finance 48% of the total investment (OCyT, 2017), should be prioritized for those projects having the most significant impacts, given that there are few resources to invest.

This study is carried out through a data panel of Colombian manufacturing companies between 2009 and 2016 generated through the Survey of Development and Technological Innovation (Encuesta de desarrollo tecnológico e innovación tecnológica-EDIT). This research aims to estimate the impact of innovation subsidies on input, output and behavioral additionality of Colombian companies in the long term.

The article is structured as follows: A brief literature review related to the evaluation of the innovation subsidies and methodologies that have been applied by researchers to solve some methodological issues. Afterwards, the methodology, data set, and variables used will be explained. In the fifth section, the results of an econometric strategy are presented, and in the final section will be the conclusions, discussion, and limitations of the study.

2. Literature review

In recent years, the literature on the effect that subsidies to innovation have on firms has grown exponentially. Generally, this literature has used innovation surveys based on the Oslo Manual (OECD, 2005) and has had to deal mainly with a problem of endogeneity, that is, subsidies are not given randomly, and therefore, they are determined by the same variables for which it is required to measure its rate of change before and after the subsidy (e.g. R&D expenditure). In such a way, multiple methodologies have been used to overcome this problem, e.g. the Heckman selection models, instrumental variables (IV), parametric matching, difference in differences (DID), and dose-response models. Each of them has different approaches, but they have as a common factor that they try to overcome the problem of endogeneity, and in some cases, as with the DID methodology, heterogeneity for not observable firm variables can also be controlled [for a thorough review of these methodologies see Cerulli (2010)].

The literature on the effect of subsidies on innovative firms began in the 2000s, seeking to determine if there was a crowding-out effect on the companies internal R&D expenditure. In general, these studies found this effect is positive, and firms receiving subsidies end up spending a higher amounts of R&D than they would have spent without the subsidy, that is, the so-called input additionality effect (Aerts & Czarnitzki, 2004; Aerts & Schmidt, 2008; Almus & Czarnitzki, 2003; Busom, 2000; Cerulli & Potì, 2008, 2016; Choi & Lee, 2017; Chudnovsky, Lopez, Rossi, & Ubfal, 2006; Cin, Kim, & Vonortas, 2017; Czarnitzki & Delanote, 2015; Czarnitzki, Ebersberger, & Fier, 2007; Czarnitzki & Hussinger, 2018; Czarnitzki & Lopes-Bento, 2012, 2013, 2014; Engel, Rothgang, & Eckl, 2016; González & Pazó, 2008; Görg & Strobl, 2007; Heshmati & Lööf, 2005; Jiang et al., 2018; Lach, 2002; Sanguinetti, 2005).

At the same time, it can be expected that the effects of innovation subsidies tend not to be exclusive for input additionality, but also on other types of variables such as behavioral ones. The idea behind the behavioral additionality is that a company, after receiving a subsidy, changes its behavior, it is managed under a new logic, and performs its innovation processes differently. Therefore, it is possible to measure such changes before and after the subsidy. Authors such as Autio, Kanninen & Gustafsson (2008) have shown that the forms of learning-related with technology, market, and internationalization increase positively after receiving a subsidy. Similarly, Clarysse, Wright, and Mustar (Clarysse, Wright, & Mustar, 2009) find that government subsidies have a substantial impact on the formalization of innovation processes, in the generation of capabilities to manage innovation, and in the research trajectories of business. In the same path, Wanzenböck, Scherngell, and Fischer (2013) show that once companies receive subsidies to innovation, the likelihood of abandoning their innovation projects decreases, the cooperative behavior increases, and the knowledge transfer flows become more visible. At the same time, Tello (2015), Busom and Vélez-Ospina (2017), and Jiang et al. (2018) show that companies receiving subsidies tend to increase their propensity to innovate. However, the literature on the effects of subsidies on behavioral additionality is not widely disseminated, and generally, literature about innovation subsidy focuses on the input additionalities of innovation (Dimos & Pugh, 2016).

Simultaneously, the effects generated by subsidies could also be measured on innovative output results; that is, subsidies can also generate output additionalities. Some researchers have shown that these effects are highly visible, and therefore, they can be taken into account as a way to evaluate R&D&i government policies. In this direction, Czarnitzki and Lopes-Bento (2014) show that companies receiving subsidies have a higher propensity to register patents; these results are in line with those by Czarnitzki, Ebersberger and Fier (2007), Czarnitzki and Delanote (2015), Widmann (2016) and Czarnitzki and Hussinger (2018). Likewise, the articles by Crespi and Maffioli (2014), Crespi et al. (G. Crespi et al., 2015), and Cin, Kim, and Vonortas (2017) show that firms in Latin America and Korea tend to improve their labor productivity after receiving an innovation subsidy. In the case of Austria, García and Mohnen (2010) indicate that the proportion of innovative sales increases by 3,4% for firms obtaining an innovation subsidy. This is a significant additionality effect, given that it is assumed that one of the main objectives of subsidies is to reduce the uncertainty of innovation projects and generate profitability for the companies receiving them. In the end, this profitability must come from a higher flow of revenues. However, Karhunen and Huovari (Karhunen & Huovari, 2015) show with data from Finland that labor productivity in SMEs seems not to be affected after a subsidy reception, even when this type of policies tends to increase the firms' human capital levels; also, Catozzella and Vivarelli (2011) show with data from Italy that innovation productivity tends to be reduced after subsidy; this could be a result of the innovation cost increase, but also because of the decrease of innovation revenues.

Researches like Aboal and Garda (2015), Crespi et al. (G. Crespi et al., 2015), Bodas-Freitas et al.(2017), Guo, Guo and Jiang (2016), and Howell (2017) show that firms receiving subsidies tend to increase their sales of innovative products, not in the short term, but the long term. The last point is essential to determine the actual additionality effects of innovation subsidies. Innovation projects usually deliver results in the long term; however, a large part of research on this topic focuses on short-term additionality effects, especially those that used propensity score matching methodologies (Zúñiga-Vicente et al., 2014). In recent years, literature has begun to show the long-term effect of subsidies by finding there are greater effects in the long term than those estimated in the short term (Bodas-Freitas et al., 2017; Cin et al., 2017; G. Crespi et al., 2015; Engel et al., 2016; Guo et al., 2016; Howell, 2017; Karhunen & Huovari, 2015; Tello, 2015; Widmann, 2016).

Similarly, as evidenced by Zúñiga-Vicente et al. (2014), studies on the additionality of subsidies are mainly focused on developed countries and have not paid much attention to these effects on developing countries. As we understand it, this fact has a fundamental justification, the lack of micro-data in which to look for evidence of additionalities in developing countries. Since the first decade of the 2000s, the exercises carried out in Europe through the Community Innovation Surveys (CIS) based on the Oslo Manual (OECD & Eurostat, 1997) have allowed the detailed study of this and other phenomena related to innovation. However, in the case of developing countries, the lack of micro-data has not allowed additionalities to be studied sequentially. However, it is possible to find some valuable examples for developing countries, especially in the case of Latin America as it can be seen in Sanguinetti (2005), Chudnovsky et al.(2006), and Crespi et al.(2016) for Argentina; Fernández-Sastre and Martín-Mayoral (2015) in the case of Ecuador; Tello (2015) for Peru; Aboal and Garda (2015) in Uruguay; Crespi et al.(G. Crespi et al., 2015), Busom and Vélez-Ospina (2017), and Barrios, Forero and Perry (2018) for the case of Colombia, and the literature review of Crespi and Maffioli (2014) for all Latin America.Methodology

It is possible to see that literature about innovation subsidies additionalities has been overlooked; first, the effects of subsidies on other variables different from the ones measuring input additionalities. Second, the long-term effects of subsidies on firms. Third, the impact of innovation subsidies on firms of underdeveloped countries. In such a way, this research is a small effort to understand the long-term input, output, and behavioral additionality for manufacturing firms in an underdeveloped country like Colombia.

3. Methodology

The method used in this research is "Conditional Difference in Differences" (CDID). This method consists in combining a parametric matching methodology with a difference in difference model, where the average differences of the control and treatment group before the subsidy are compared against the same differences after the subsidy granted in the follow-up period.

For our data, we do not have a randomized experiment since subsidies are not given randomly. Therefore, it is not possible to compare directly firms receiving subsidies against companies that do not receive them, because their initial and final conditions are differentiated by other factors different from subsidies. That is the reason why the first step of the CDID methodology is to use a matching method. With this technique, it is possible to identify a subsided company and their counterpart, i.e., another firm that does not receive subsidies, but with the same likelihood of receiving government aid, and therefore, with similar characteristics compared with a subsided firm before receiving grants. This is done through a set of observable firm characteristics. This pairing method, called propensity score matching (PSM), allows us to return to the conditions of a randomized experiment (Chudnovsky et al., 2006) in which the results of input, output, and behavioral variables are compared in the base year (2010). The PSM consists of determining the average treatment effect on the treated (ATET):

(1) $ATET = E(Y_{i1}|D_i = 1) - E(Y_{i0}|D_i = 1)$

Where Di is a dichotomous variable with the value one (1) if the firm received subsidies, and zero (0) otherwise. Y_{i1} is the response variable being measured for firms with a subsidy, i.e., in the treatment group, and Yi0 is the response variable being measured for firms without subsidy, i.e., in the control group. In the case of innovation subsidies, response variables could be grouped on input, output and behavioral variables.

The term $E(Y_{i1} |D_i = 1)$ indicates the average effect of the response variable Y_i for a company in the treatment group and receiving subsidies, and $E(Y_{i0} |D_i = 1)$ reflects the average effect of the response variable for a company in the control group and receiving subsidies. However, the last term is not observable and is counterfactual, since the effect of the subsidy cannot be seen in a company that did not receive it; therefore, this value must be estimated.

Assuming a CIA (Conditional Independence Assumption) between subsidies and the response variable, a set of observable characteristics Xi, used to select granted firms could be applied to determine the outcomes of non-treated (control) firms. Therefore, it can be said that:

(2) $E(Y_{i0} |X_i,D_i = 1) = E(Y_{i0} |X_i,D_i = 0)$

That is, it can be assumed that taking into account the set X_i of variables, the expected value of Y_i for companies belonging to the control group and receiving subsidies (counterfactual) must be identical to the non-observable value of variables in control group not receiving subsidies. Rosenbaum and Rubin (1983) addressed this issue, demonstrating that, if CIA is valid, this problem is facilitated by reducing the set of variables Xi in a single index, called propensity score, as long as it is consistently estimated by a parametric model, in this case, a probit model:

(3) $Pr(D_i = 1| X_i) = F(X_i) = \int_{-\infty}^{X_i} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{1}{2}(X_i)^2\right) dx$

The probit model result is the estimated likelihood of a firm to be granted by government subsidies, and it is used to match treated and control firms. Keeping this in mind, the calculation of ATET will be:

(4) $ATET = E(Y_{i1}|X_i,D_i = 1)-E(Y_{i0}|X_i,D_i = 0)$

However, given that we want to determine the long-term effect of subsidies using panel data, the way to implement this methodology is through a DID procedure:

(5) $ATET_t = E(Y_{i1t}|X_{it-1},D_{it} = 1,D_{it-1}=0)-E(Y_{i0t}|X_{it-1},D_{it}=0, D_{it-1}=0))$

The explained methodology allows us to control by observed heterogeneity and counterfactuality through the matching procedure; at the same time, the use of a DID procedure allows us to control by non-observable invariant firm characteristics (Aerts & Schmidt, 2008). The CDID procedure was developed with the methodology proposed by Villa (2016)I present the features of the user-written command diff, which estimates difference-in-differences (DID.

4.1. Data

The data set used for this study was developed by the National Administrative Department of Statistics (DANE, for its acronym in Spanish) in the Survey of Development and Technological Innovation (Encuesta de desarrollo tecnológico e innovación tecnológica [EDIT]). EDIT is a biennial survey, and we use EDIT V (2009 – 2010), EDIT VI (2011 – 2012), EDIT VII (2013 – 2014), and EDIT VIII (2015-2016). The survey follows the methodology of the Oslo Manual (OECD, 2005) and Bogotá's Manual (Jaramillo, Lugones, & Salazar, 2000) to collect firm-level characteristics like the amount of R&D expenditures, cooperation activities, R&D labor, among others. This survey was developed for manufacturing firms, and it is statistically representative at a national level.

The variables used are divided into four groups. The first one is the group used to generate our propensity score using a probit model. The second group of variables is the one measuring input additionalities of firms. The third group measures behavioral additionalities. The last one measures output additionalities. Description of variables can be seen in Appendix A.

We use the 2010 survey as our base treatment moment and 2016 as the follow-up year. The objective behind this was to measure long-term additionalities of firms receiving subsidies. We use firms with more than ten employees and not receiving subsidies in the period 2008-2009. At the same time, we divided our firms into SMEs and big firms to confirm if the additionalities affect in different ways those types of firms; A summary of our data used can be seen in Appendix B.

4. Results

To perform our matching methodology, we use a probit model in which variables related to subsidies granting are included (see Appendix A). This regression was performed for firms of the 2010 survey. Results of this model are posted in Table 1.

Table 1 Probit model regression

Probit model for companies with more than ten employees. Survey 2010. Firms are not receiving subsidies in 2008-2009.

	Coef.	P>|Z|	Std. error
lnsize	0,274	0,001***	0,085
medium_tech	0,332	0,237	0,281
medhigh_tech	0,566	0,026**	0,255
high_tech	0,570	0,157	0,403
and_reg	5,101	0,000***	0,520
bog_reg	5,127	0,000***	0,525
_cons	-8,627		

Number of observations: 736
Prob> chi2=0,000
*** p<0.01; ** p<0.05; * p<0.1

Source: Our own calculations.

Variables like firm size, belonging to medium-high technology industries, and firm location in principal geographic areas like Bogotá and Andean Region seem to be related to subsidies in Colombia. After this procedure, we perform several t-tests on the equality of means of Appendix A variables related to input, output, and behavioral additionalities. The result of these tests can be seen in Table 2. Before the matching procedure, control firms tend to have a higher number of employees and belong in more significant proportions to high and medium technology sectors. However, after the matching procedure, differences disappear, and therefore, we are ready to perform a difference in difference procedure given that control and treated firms seem to have no differences. In appendix C. we have included a common support analysis in order to understand if, after matching, the balancing property is satisfied. As the reader may appreciate, after the fourth block, we reach the balancing property using 736 firms; therefore, we can now the average treated effect on the treated using the difference in difference procedure.

Table 2. T-test on equality of means. Treated Vs. control firms in 2010 survey

T-Test for treated and control firms before and after the balance
All firms with more than ten employees. Survey 2009-2010. Firms' non-receiving subsidy in the period 2007-2008.

	Differences before matching [Treated-Control]	*Prob.*	*Differences after matching [Treated-Control]*	*Prob.*
lnsize	-0,886	0,004***	-0,053	0,603
medium_tech	-0,003	0,974	-0,044	0,137
medhigh_tech	-0,187	0,055*	-0,058	0,103
high_tech	-0,031	0,646	-0,005	0,827
and_reg	-0,113	0,327	0,051	0,165
bog_reg	-0,110	0,339	0,058	0,111

*** p<0.01; ** p<0.05; * p<0.1
Treated firms 21. Control firms 715. Total firms 736.
Source: Own calculations

We calculate ATET with 2010 as our base period and 2016 as our follow-up period. Results of this procedure can be seen in Table 3.

Table 3. Average Treatment Effect on the Treated (ATET). All firms included.

Difference in differences procedure for all firms in the sample. Firms with more than ten employees. Base period=2010; Follow up period=2016

Type of additionality	Variable	*base period diff (treated - control)*	*follow-up period diff (treated - control)*	*diff in diff (Follow up - Base period)*	*P>| t |*
input	rdint	-0,746	0,445	1,191	0,000***
	rdext	0,289	0,004	-0,285	0,001***
	expinn	-0,457	0,449	0,906	0,012***
	rd_size	-10,667	16,691	9,896	0,006***
behavioral	ongoing	0,012	-0,055	-0,068	0,249
	imp_fin_internal	-0,005	0,080	0,085	0,150
	imp_innprofit	-0,085	-0,153	-0,068	0,249
	imp_fin_ext	0,174	0,206	0,031	0,585
	coop_total	0,217	0,221	0,005	0,929
	coop_amplitude	1,263	0,653	-0,610	0,016**
output	dummypatents	-0,086	-0,050	0,036	0,125
	tmarks_ip	-0,047	-0,026	0,021	0,718
	nfnatsales	0,220	0,086	-0.135	0,021**

*** p<0.01; ** p<0.05; * p<0.1
Number of observations in the base period 736 (21 treated, 715 controls); the number of observations in follow up period 522 (39 treated, 483 controls).
Source: Own calculations.

It can be seen that when we included all firms in our analysis, input additionalities tend to be strong. Differences in internal R&D expenditures move from being negative in favor of non-subsided control firms to being positive in favor of treated firms for almost 1.2 million COP. Therefore, we can discard a crowding-out effect related to internal R&D. However, external expenditures on R&D move in the other direction. In 2010, treated firms expended more than control firms did, but in 2016, this situation reversed. It seems that subsided firms tend to diminish their external expenditure. Apparently, in the long term, firms tend to privilege the internal formation of capabilities and diminish external knowledge acquisition. This is, in the long term, companies tend to generate its knowledge in house, instead of buying it. The sum of total R&D and innovation seems to increase as a result of a higher effect of internal R&D in almost 0,9 million COP. Employees related to R&D in 2010 were higher for control firms; however, after subsidies, treated firms tended to have almost ten more employees than non-subsidized control firms. This is important given that we assume these types of employees have high qualifications. Therefore, innovation subsidies create high-value employment.

Results for behavioral additionalities are no good. Treated firms do not elevate the number of ongoing projects and do not improve their perception of innovation barriers. However, treated firms diminish their cooperation amplitude; that is, these firms tend to collaborate with fewer types of institutions. We interpreted these results as a cooperation specialization, i.e., firms tend to privilege relationships with fewer types of institutions but might be increasing the strength of those relationships.

Output results show that patents and trademarks have no effects when the full sample is used. Innovation revenues, on the other side, seem to have negative additionalities, that is, differences of control and treated firms tend to decrease in the long run in favor of control firms. Given that we are using only revenues for new to the firm products and services as a way to measure innovation output, we believe this result could be an outcome of a dichotomy between new to the market revenues and new to the firm revenues. Our sales variable was constructed using a percentage of total new to the firm innovative revenues, and then we re-expressed this number into a dummy variable. It is possible that the percentage of new to the market revenues increases while the complement percentage of new to the firm revenues decreases. Maybe, the negative sign of our sales variable could be the result of non-observed additionality on new to the market innovative revenues. However, we cannot confirm this as we do not have enough observations for new to the market revenues. Another plausible explanation of the negative sign could be the low efficiency of externally funded innovation expenditures against private funding expenditure as it was founded by Catozzella and Vivarelli (2011).

4.2. Results on small and medium enterprises

When the procedure is developed for SMEs, the results are quite interesting and can be seen in Table 4. In the first place, SMEs present a significant crowding-out effect for internal R&D expenditure. That is, SMEs tend to expend less money on internal R&D after subsidies. This result is contrary to the one obtained when we used the full sample; this is interesting since we can say not all firms tend to act in the same way after subsidies. At the same time, SMEs tend to expend more money on external R&D acquisition; therefore, we can say these firms tend to privilege external over internal knowledge after subsidies. When we measure the effect over total R&D, the decreasing effect of external knowledge acquisition is higher than the one of internal R&D. Therefore, there is a crowding-out effect on total R&D expenditure. Simultaneously, R&D employment tends to increase for subsided SMEs; on average, in the long term, subsided SMEs augmented R&D employees more than the control SMEs in 4,3 employees.

Regarding behavioral additionalities, results are interesting, too. Ongoing innovation projects tend to increase for SMEs after subsidy; that is, firms with an active project in the survey period are 21% higher for subsided against control companies. Impediments regarding internal and external funding tend to increase for treated firms also; this seems to be a negative result given that firms tend to perceive more financial barriers after than before subsidy. However, we have a plausible explanation for this result; in several researches like the ones of Baldwin and Lin (2002), D'Este, Iammarino, Savona and Von Tunzelmann (2012) or Pellegrino and Savona (2017), it has been found that some financial impediments tend to increase after a firm generates some experience on innovation ventures. The reason behind this is there are some firms without innovation projects, which tend to respond "no" to the question: Does your firm perceive a financial impediment to perform innovative projects in the last year? because they have no experience in day-by-day innovation projects. However, firms tend to have a higher perception of impediments after they involve on more R&D ventures because they begin to understand the way innovation is made. Overall, we consider this result can be a signal of firms gathering experience on innovation projects; therefore, we hypothesize it is an experience effect that could not be possible if these firms did not receive subsidies. At the same time, the perception that innovation has not been profitable tends to decrease, and we believe this is also an experience effect created by the possibility to involve in R&D ventures after receiving subsidies. On the other side, we do not find any changes in cooperation variables or innovation output variables.

Table 4. Average Treatment Effect on the Treated (ATET). SME's.
Difference in differences procedure for SME's. Firms with more than ten and less than 200 employees. Base period=2010; Follow up period=2016

Type of additionality	Variable	base period diff (treated - control)	follow-up period diff (treated - control)	diff in diff (Follow up - Base period)	P>| t |
input	rdint	0,064	-0,007	-0,071	0,000***
	rdext	-0,003	0,003	0,005	0,008***
	expinn	0,061	-0,005	-0,066	0,000***
	rd_size	-0,426	3,850	4,276	0,001***
behavioral	ongoing	-0,103	0,111	0,214	0,008***
	imp_fin_internal	-0,314	-0,018	0,296	0,000***
	imp_innprofit	0,165	-0,022	-0,187	0,019**
	imp_fin_ext	-0,260	0,077	0,338	0,000***
	coop_total	0,383	0,358	-0,025	0,729
	coop_amplitude	1,237	0,888	-0,349	0,162
output	dummypatents	-0,011	0,074	0,085	0,003
	tmarks_ip	-0,158	0,162	-0,004	0,962
	nfnatsales	0,245	0,213	-0,031	0,686

*** p<0.01; ** p<0.05; * p<0.1
Number of observations in the base period 448 (8 treated, 440 controls); the number of observations in follow up period 254 (12 treated, 242 controls).
Source: Own calculations

4.3. Results on big firms

As can be seen in Table 5, big firms treated tend to have more R&D internal expenditures than control firms do in the long term; therefore, we can say big firms in Colombia behave differently than SMEs, given that for the latter we found a crowding-out effect. At the same time, expenditures for acquiring external R&D tend to decrease in those types of firms. It seems that treated big firms tend to replace external by the internal generation of knowledge. At the same time, total expenditure seems to have no changes in the long term and in sum, it seems that the additionality of internal expenditure is controlled by the additionality of external expenditures on R&D.

When we break down results of behavioral additionalities, it can be seen that treated firms having ongoing innovation projects seem to diminish against non-treated control firms; this could be interpreted as a counterintuitive result, but it is also possible that big firms tend to choose those projects in which they expect higher profits or those for which they have enough funding, diminishing ongoing projects in consequence. However, this result is to be researched in the future. By combining results of internal R&D expenditure with those of the dummy of ongoing projects, we can expect that individual projects of big firms tend to be highly specialized and to have higher amounts of money.

Table 5. Average Treatment Effect on the Treated (ATET). Big firms.

Difference in differences procedure for big firms. Firms with more than 200 employees. Base period=2010; Follow up period=2016					
Type of additionality	Variable	base period diff (treated - control)	follow-up period diff (treated - control)	diff in diff (Follow up - Base period)	P>| t |
input	rdint	-0,148	0,608	0,756	0,095*
	rdext	0,701	0,005	-0,696	0,000***
	expinn	0,553	0,613	0,060	0,907
	rd_size	-30,045	-9,088	20,957	0,005***
behavioral	ongoing	0,032	-0,195	-0,227	0,018**
	imp_fin_internal	0,186	0,183	-0,003	0,976
	imp_innprofit	-0,165	-0,285	-0,120	0,224
	imp_fin_ext	0,463	0,294	-0,169	0,075*
	coop_total	0,166	0,056	-0,11	0,223
	coop_amplitude	1,678	0,480	-1,198	0,010**
output	dummypatents	-0,069	-0,066	0,003	0,924
	tmarks_ip	-0,023	-0,064	-0,041	0,664
	nfnatsales	0,215	0,024	-0,191	0,058*

*** p<0.01; ** p<0.05; * p<0.1

Number of observations in the base period 257 (13 treated, 244 controls); the number of observations in follow up period 177 (27 treated, 150 controls).

Source: Own calculations

Regarding external financial impediments, big firms tend to perceive fewer barriers after subsidy; this is contrary to what happens with SMEs. We believe big firms have already experienced innovation projects; therefore, those firms tend to decrease external financial impediments as a result of a positive innovation subsidy spillover. At the same time, cooperation amplitude is lower for big firms receiving subsidies; our interpretation of this result is that those firms tend to specialize their cooperation networks going from an atomized network to a specialized one.

Finally, results of output additionalities show us that big firms, just like SMEs do not have more patents or trademarks after subsidies, at the same time, and in the same direction of the results of the full sample, innovative revenues tend to decrease as firms receive more subsidies; we do not fully understand this results, but the same hypothesis posted for the full sample could apply in the case of big firms.

5. Robustness check

Lastly, as a robustness check, we perform several falsification tests for the period 2010. Let´s remember that for our analysis, we use companies without subsidies in the period 2007-2008; therefore, we replicate our matching procedure for the 2008 survey and then, we test the impact of subsidies on several variables for the follow-up period of 2010. Given that in our sample, we have companies not receiving subsidies in the 2007-2008 period, firms should not display any effect linked to subsidies in the period 2010.

For our test we use variables like industrial secret (*ind_sec*, a dummy variable equal to one if the company protect its ideas with this type of protection and zero otherwise); non-disclosure agreements (*non_disa,* a dummy variable equal to one if the company protect its ideas with this type of protection and zero otherwise); number of quality certifications obtained by the company in this period (*cert_num*); a variable taking into account if the company is using data from research centers or commerce chambers to generate innovation ideas (*data_rcts; data_cc*); and lastly, a dummy variable taking into account if the company perform innovation to improve quality of its goods and services (*imp_gs*). The selection of these variables lies in the fact that are measures that should not be affected by subsidies reception, and, as can be seen in appendix D., the checks confirm our inferences, the variables studied are not affected by subsidies in 2010.

6. Conclusions

We developed a Conditional Difference in Difference methodology to determine the input, output, and behavioral additionality effects of subsidies to innovation for firms in Colombia, in the 2010-2016 period, using Colombia´s innovation survey (EDIT). Our results reinforce the fact that innovation subsidies create positive additionalities on firms. Those additionalities can be seen in the long term, especially for input variables like internal R&D expenditures (rdint), total R&D expenditures (expinn), and the number of R&D employees (rd_size).

On the other hand, we found that external expenditures on R&D (rdext) tend to be reduced after subsidies, and we believe this is an effect of internal knowledge generation against external acquisitions. This effect is visible especially, for big firms and the complete sample, and reinforces the fact that governments can reduce market imperfections using subsidies, given that most of the companies, tend to privilege the internal knowledge formation that generates internal spillover effects. For manager proposes, these results are essential. Also, companies without experience in the innovation field, can use government subsidies as a way to gain the initial needed capabilities in the process, even when this knowledge is obtained outside the company.

We found that behavioral additionalities are positive in the case of small and medium firms; these companies tend to increase the number of ongoing innovation projects showing that government subsidies induce companies to involve into innovation in the long-term. At the same time, we found out that the perception of internal and external financial impediments tend to increase after subsidies in SMEs. These results seem to be contra-intuitive, because one may think that firms should reduce their financial impediments perception once subsidies are granted; however, we hypothesize that most SMEs are not experienced in innovation; therefore, this is the result of a new vision of these firms about the innovation process. As is discussed in literature (Baldwin & Lin, 2002; D'Este et al., 2012; Pellegrino & Savona, 2017), we call this phenomena the experience effect; companies perceive impediments to innovation only after the involvement on innovation process, therefore, subsidies increase impediments perception given that before grants, SMEs are mostly not involved in innovation ventures. At the same time, another way to see this experience effect is that SMEs tend to perceive that innovation is more profitable once they receive subsidies. A company cannot say that innovation is good business without performing innovation projects, and only after the reception of subsidies, followed by involvement in innovation projects, companies perceive the benefits of the process.

On the other side, we find out that big firms, after subsidy grants, tend to diminish their perception of external financial barriers (imp_fin_ext). In contrast to SMEs findings, it seems that big firms, that are experienced already, find relief in their financial impediments perception; This could be a proof for the experience effect generated in SMEs, given that is logic to think that big firms are already involved in innovation projects, and therefore, have lived in firsthand the effect of financial impediments, so subsidies, create the expected effect on big firms, diminishing obstacle´s perception.

Output additionalities do not have positive results in our research. Patents and trademarks are not affected after subsidies; however, we found a negative impact on firm revenues only for big firms. Although we do not fully understand this phenomenon, we believe this could be caused by the way we measure revenues (new to the firm), and possibly, is non-observed additionality on new to the market revenues, that is, the weighted complement of our measure. The fact that we cannot find any output additionalities lead us to look for other ways to measure these type of impacts, and the CDM model (Crepon, Duguet, & Mairessec, 1998), could be a right approach in the case of productivity increase related to subsidies, even when recent literature point out to a negative result in this field (Czarnitzki & Delanote, 2017).

Our results have important messages for policymakers. For one side, in contrast to big firms, SMEs in Colombia seem to have stable additionalities produced by subsidies. Therefore, policies to innovation should privilege the selection of SMEs that most of the time are not involved in innovation, given that subsidies introduce an experience effect, making companies get involved in innovation ventures. However, must of the time, innovation policies are directed to big firms given the logic of "picking the winner" used by governments around the world. Our results point out that this type of policy should produce minor effects on market spillovers.

Second, dividing our sample, we found out that big firms and SMEs tend to behave differently after subsidies; therefore, policymakers should avoid programs in which all companies are considered under the same umbrella. If behavior after subsidy is dissimilar, program characteristics should be also different in order to increase the likelihood of obtaining innovation spillover in each type of company, in this case, SMEs and big firms.

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Appendix A. Summary of used variables

	Variable	Description	Measurement
Probit	treated	The firm receives subsidies in that particular year.	Dummy 1=yes; 0=no
	lnsize	Number of employees	Natural logarithm of employee's number
	medium_tech	Belonging to a medium technology sector	Dummy 1=yes; 0=no
	medhigh_tech	Belonging to a medium high technology sector	Dummy 1=yes; 0=no
	high_tech	Belonging to a high technology sector	Dummy 1=yes; 0=no
	and_reg	Firm located in Andean Region	Dummy 1=yes; 0=no
	bog_reg	Firm located on Bogotá	Dummy 1=yes; 0=no
Input	rdint	Mean of internal expenditure on R&D in t and t-1	Millions of COP$
	rdext	Mean of external expenditure on R&D in t and t-1	Millions of COP$
	expinn	Mean of total expenditure on R&D in t and t-1	Millions of COP$
	rd_size	Mean of FTE R&D employees	Number of employees
Behavioral	ongoing	Does the firm have ongoing R&D projects?	Dummy 1=yes; 0=no
	imp_fin_intl	Does the firm perceive a lack of internal financial founds?	Dummy 1=yes; 0=no
	imp_innprofit	Does the firm perceive that innovation is not profitable?	Dummy 1=yes; 0=no
	imp_fin_ext	Does the firm perceive a lack of external financial founds?	Dummy 1=yes; 0=no
	coop_total	Does the firm cooperate for R&D in the last two years?	Dummy 1=yes; 0=no
	coop_amplitude	Types of institutions in which cooperation is carried out	Number of typologies, max=11
Output	dummypatents	Does the firm have patents?	Dummy 1=yes; 0=no
	tmarks_ip	Does the firm have trademarks?	Dummy 1=yes; 0=no
	nfnatsales	Does the firm have innovative new for the firm national revenues?	Dummy 1=yes; 0=no

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Appendix B. Descriptive statistics

	2010 survey										
	Subsidy?	not treated					treated				
	Variable	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
	treated	715	0,00	0,00	0,00	0,00	21	1,00	0,00	1,00	1,00
	lnsize	715	4,83	1,25	2,44	8,27	21	5,71	1,38	2,94	7,44
	medium_tech	715	0,24	0,42	0,00	1,00	21	0,24	0,44	0,00	1,00
Probit	medhigh_tech	715	0,24	0,43	0,00	1,00	21	0,43	0,51	0,00	1,00
	high_tech	715	0,06	0,25	0,00	1,00	21	0,10	0,30	0,00	1,00
	and_reg	715	0,46	0,50	0,00	1,00	21	0,57	0,51	0,00	1,00
	bog_reg	715	0,32	0,47	0,00	1,00	21	0,43	0,51	0,00	1,00
	rdint	715	0,15	1,18	0,00	27,91	21	0,56	0,92	0,00	3,16
Input	rdext	715	0,03	0,27	0,00	4,69	21	0,55	1,34	0,00	4,39
	expinn	715	0,18	1,35	0,00	32,26	21	1,12	1,76	0,00	4,68
	rd_size	715	15,02	44,50	0,00	892,00	21	18,12	20,32	0,50	61,00
	ongoing	715	0,63	0,48	0,00	1,00	21	0,67	0,48	0,00	1,00
	imp_fin_intl	715	0,41	0,49	0,00	1,00	21	0,38	0,50	0,00	1,00
Behavioral	imp_innprofit	715	0,44	0,50	0,00	1,00	21	0,38	0,50	0,00	1,00
	imp_fin_ext	715	0,33	0,47	0,00	1,00	21	0,48	0,51	0,00	1,00
	coop_total	715	0,57	0,50	0,00	1,00	21	0,86	0,36	0,00	1,00
	coop_ampli~e	715	1,49	1,87	0,00	11,00	21	3,10	2,23	0,00	8,00
	dummypatents	715	0,03	0,17	0,00	1,00	21	0,00	0,00	0,00	0,00
Output	tmarks_ip	715	0,50	0,50	0,00	1,00	21	0,52	0,51	0,00	1,00
	nfnatsales	715	0,39	0,49	0,00	1,00	21	0,57	0,51	0,00	1,00

	2016 survey										
	Subsidy?			not treated					treated		
	Variable	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
	treated	483	0,00	0,00	0,00	0,00	39	1,00	0,00	1,00	1,00
	lnsize	483	5,10	1,31	2,44	8,35	39	5,43	1,45	3,18	8,43
	medium_tech	483	0,18	0,38	0,00	1,00	39	0,28	0,46	0,00	1,00
Probit	medhigh_tech	483	0,24	0,43	0,00	1,00	39	0,32	0,48	0,00	1,00
	high_tech	483	0,06	0,25	0,00	1,00	39	0,04	0,20	0,00	1,00
	and_reg	483	0,46	0,50	0,00	1,00	39	0,64	0,49	0,00	1,00
	bog_reg	483	0,34	0,47	0,00	1,00	39	0,28	0,46	0,00	1,00
	rdint	483	0,48	5,01	0,00	115,30	39	1,50	3,38	0,00	12,23
Input	rdext	483	0,03	0,17	0,00	3,03	39	0,04	0,06	0,00	0,19
	expinn	483	0,50	5,06	0,00	116,21	39	1,54	3,41	0,00	12,37
	rd_size	483	16,29	27,44	0,50	252,00	39	27,30	32,25	3,00	117,50
	ongoing	483	0,51	0,50	0,00	1,00	39	0,68	0,48	0,00	1,00
	imp_fin_intl	483	0,21	0,41	0,00	1,00	39	0,24	0,44	0,00	1,00
	imp_innprofit	483	0,14	0,35	0,00	1,00	39	0,16	0,37	0,00	1,00
Behavioral	imp_fin_ext	483	0,14	0,35	0,00	1,00	39	0,16	0,37	0,00	1,00
	coop_total	483	0,43	0,50	0,00	1,00	39	0,56	0,51	0,00	1,00
	coop_amplitude	483	1,17	1,70	0,00	8,00	39	2,52	3,07	0,00	11,00
	dummypatents	483	0,04	0,21	0,00	1,00	39	0,16	0,37	0,00	1,00
Output	tmarks_ip	483	0,69	0,46	0,00	1,00	39	0,84	0,37	0,00	1,00
	nfnatsales	483	0,53	0,50	0,00	1,00	39	0,56	0,51	0,00	1,00

Appendix C. Common support analysis

	Variable	lnsize C	lnsize T	medium_tech C	medium_tech T	medhigh_tech C	medhigh_tech T	high_tech C	high_tech T	and_reg C	and_reg T	bog_reg C	bog_reg T
Block 1	obs	687	14	687	14	687	14	687	14	687	14	687	14
	mean	4,74	4,90	0,24	0,21	0,22	0,29	0,06	0,14	0,45	0,57	0,32	0,43
	diff	-0,16		0,03		-0,07		-0,08		-0,12		-0,11	
	p value	0,63		0,81		0,56		0,24		0,38		0,37	
Block 2	obs	20	1	20	1	20	1	20	1	20	1	20	1
	mean	6,45	7,43	0,05	1,00	0,85	0,00	0,00	0,00	0,60	1,00	0,40	0,00
	diff	-0,98		-0,95		0,85		0,00		-0,40		0,40	
	p value	.		.		.		.		.		.	
Block 3	obs	7	3	7	3	7	3	7	3	7	3	7	3
	mean	6,84	7,19	0,14	0,33	0,57	0,66	0,29	0,00	0,57	0,00	0,43	1,00
	diff	-0,35		-0,19		-0,09		0,29		0,57		-0,57	
	p value	0,20		0,54		0,81		0,36		0,11		0,11	
Block 4	obs	1	3	1	3	1	3	1	3	1	3	1	3
	mean	7,72	7,39	0,00	0,00	1	1,00	0,00	0,00	1,00	1,00	0,00	0,00
	diff	0,33		0,00		0,00		0,00		0,00		0,00	
	p value	.		.		.		.		.		.	

*** p<0.01; ** p<0.05; * p<0.1

T=Treated; C=Control. N=736 firms

After block 4, there are no controls. For single observations, there are no Standard Deviations; therefore, we cannot calculate P.Values for blocks 2 and 4.

Appendix D. Falsification tests

Falsification test.
Difference in differences procedure for firms with more than ten employees and receiving subsidy in 2010.
Base period=2008; Follow up period=2010

Type of additionality	Variable	*base period diff (treated - control)*	*follow-up period diff (treated - control)*	*diff in diff (Follow up - Base period)*	*P>| t |*
Not related with subsidies	ind_sec	-0,078	-0,122	-0,044	0,309
	non_da	-0,111	-0,097	0,014	0,804
	cert_num	-3,334	-1,482	1,852	0,605
	data_rcts	-0,097	-0,094	0,003	0,936
	data_cc	-0,007	-0,003	0,004	0,521
	imp_gs	0,105	0,079	-0,026	0,694

*** p<0.01; ** p<0.05; * p<0.1
Number of observations in the base period 454 (12 treated, 442 controls); the number of observations in follow up period 259 (14 treated, 245 controls).

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