Diverse knowledge for diverse innovation; evidence from Chilean firms

Conocimientos diversos para innovaciones diversas, evidencia de firmas chilenas.

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Abstract

Using the Chilean Innovation Survey for 2019-2020, this work studies the effects of different knowledge sources on a range of innovation outputs. Findings reveal distinct impacts of sourcing information from competitors, customers, and government agencies on product, process, marketing, organizational, and social innovation outputs. Information from customers has a positive effect on overall innovation. Social innovation is positively influenced by information sourced from government agencies. These findings contribute to the understanding of how different knowledge sources shape innovation outputs on developing countries. They provide valuable insights for firms, policymakers, and researchers seeking to enhance innovation capabilities and inform evidence-based policies.

Key words: *Innovation output, Diverse knowledge sources, Chilean Innovation survey, Binary instrumental variable model.*

JEL Classification: *O31, O32, D22.*

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Resumen

Utilizando la Encuesta de Innovación de Chile para 2019-2020, este trabajo estudia los efectos de diferentes fuentes de conocimiento en una variedad de resultados de innovación. Los hallazgos revelan distintos impactos de la obtención de información de competidores, clientes y agencias gubernamentales en los resultados de innovación social, organizacional, de marketing, de procesos y de productos. La información de clientes tiene un efecto positivo en la innovación general. La innovación social se ve influenciada positivamente por la información procedente de agencias gubernamentales. Estos hallazgos contribuyen a comprender cómo las diferentes fuentes de conocimiento dan forma a los resultados de la innovación en los países en desarrollo. Proporcionan información valiosa para empresas, formuladores de políticas e investigadores que buscan mejorar las capacidades de innovación e informar políticas basadas en evidencia.

Palabras clave: *Resultados de innovación, Diversas fuentes de información, Encuesta de innovación chilena, Modelo de variable instrumental binaria.*

Clasificación JEL: *O31, O32, D22*

1. Introduction

Innovation has long been recognized as a crucial driver of economic growth and competitiveness. As societies and economies become increasingly complex and interconnected, the ability of firms to adapt and innovate becomes ever more essential. Understanding the factors that contribute to successful innovation is therefore of paramount importance for policymakers, researchers, and business leaders alike. It has been widely acknowledged that firms need to look beyond their internal resources and tap into external knowledge to foster innovation. However, the specific mechanisms through which diverse knowledge sources influence innovation outcomes require further investigation.

Over the years, scholars have made significant progress in developing models to comprehend the dynamics of innovation. Data collected through innovation surveys has played a pivotal role in unraveling the causality behind innovation success. By examining various firm-level variables, such as research and development (R&D) expenditure, human capital, sales, and total employees, researchers have sought to identify the determinants of innovation output.

However, a fundamental question remains: Are there specific variables that have distinct impacts on specific types of innovation outputs? To shed light on

this matter and disentangle the intricate causal relationships behind innovation success, it is crucial to develop robust models that consider bidirectional effects. The more we understand which factors contribute to specific types of innovation, the better equipped we are to formulate effective government policies that promote desirable outcomes for local economies, particularly in developing countries.

While previous studies have shed light on the effects of knowledge sources on innovation performance in various contexts, there is a need to explore these issues within the unique context of Chilean firms. Chile is a dynamic and emerging economy that has made significant efforts to foster innovation and entrepreneurship. Therefore, examining the role of diverse knowledge in Chilean firms' innovation outputs can provide a broader understanding of innovation dynamics in emerging economies.

Building upon the seminal work of Cohen and Levinthal (1990), this paper focuses on the firm's capacity to acquire and utilize information from diverse sources as a critical determinant of innovation. Recognizing the importance of addressing endogeneity concerns, our approach draws inspiration from the work by Crepon, Duguet, and Mairesse (1998).

The primary objective of this paper is to estimate an empirical model that reveals the causal relationships between different types of information sources and various forms of innovation output. To accomplish this, we leverage reliable innovation survey data collected in Chile during the period of 2019-2020. Our model considers the evolution of empirical research on the determinants of innovation output and employs instrumental variables to estimate a binary treatment model with idiosyncratic average effects.

Our findings demonstrate that the utilization of diverse innovation information sources has varying impacts on different types of innovation outputs, each with its unique magnitude. Notably, while information sourced from customers positively influences most types of innovation, we found no discernible effect from information obtained from competitors. Furthermore, government information emerges as a particularly valuable resource, benefiting social innovation significantly while also exhibiting positive effects on process and organizational innovations.

By shedding light on the intricate relationships between information sources and innovation outputs, this study provides valuable insights for policymakers, researchers, and firms seeking to enhance their innovation capabilities. The empirical evidence presented herein serves as a foundation for evidence-based policy recommendations aimed at fostering specific types of innovation that can drive the local economies of developing countries forward.

Overall, this research contributes to the existing literature by offering a comprehensive analysis of the role of diverse knowledge in driving diverse

innovation outcomes. By highlighting the nuanced relationships between information sources and innovation outputs, we aim to stimulate further research and inform strategic decision-making processes in both the public and private sectors.

The rest of this paper is structured as follows. Section 2 presents a literature review with previous findings in the topic of this work. Section 3 proposes a theoretical model by which the variables are related. Section 4 presents the database while section 5 presents the empirical strategy. Results are discussed on section 6 and section 7 concludes with a discussion about the value of our findings.

2. Previous Literature

RESEARCH ON INNOVATION PERFORMANCE

This literature review firstly highlights the importance of investigating innovation performance and its determinants in various contexts. Understanding the factors that contribute to successful innovation outcomes is crucial for firms and policymakers alike. By reviewing previous studies on innovation performance, this paper aims to contribute to the existing body of knowledge by examining the role of diverse knowledge in fostering innovation, specifically focusing on evidence from Chilean firms.

By examining the literature on innovation performance, this paper aims to discuss the importance of external knowledge, ownership structure, organizational practices, sectoral differences, customer participation, and the effectiveness of different knowledge sources in driving innovation. Understanding these factors can help firms and policymakers develop strategies and policies that promote innovation and enhance overall economic performance.

Numerous studies have focused on investigating innovation performance and its determinants. Crepon, Duguet, and Mairesse (1998) developed a model that established a framework for exploring the causation of innovation output and productivity growth by linking innovation survey variables. Building on this model, subsequent research has further examined the relationship between innovation survey variables and innovation output.

The importance of external knowledge for innovation has been emphasized in various studies. Sofka and Grimpe (2010) argued that firms should develop strategies to leverage external information, and the success of this strategy significantly influences innovation outcomes. They demonstrated that combining in-house R&D investments with a market-oriented search strategy enhances the effectiveness of innovation efforts.

Ownership structure has also been identified as a factor influencing innovation performance. Choi, Lee, and Williams (2011) found that firms with foreign ownership have a higher probability of successful innovation. Their study, conducted on Chinese firms, revealed that foreign ownership and affiliation with a business group strongly influence the volume of patent registrations. This suggests that ownership structure plays a vital role in determining innovation outcomes.

Organizational practices have been recognized as crucial factors for innovation success. Mol and Birkinshaw (2014) highlighted the significance of certain organizational practices in fostering innovation. They emphasized the role of external involvement in the innovation management process, which not only provides direct input from external change agents but also brings prior external experience as an internal agent of change.

Analyzing sectoral differences in innovation outcomes is also important. Castellacci (2008) presented a sectoral taxonomy that integrated manufacturing and service industries within a comprehensive framework. This approach underscored the increasing importance of vertical linkages and inter-sectoral knowledge exchanges between these interconnected branches of the economy. Božić and Mohnen (2016) conducted a quantitative analysis using Croatian Community Innovation Survey data and found that while there are some differences, service and manufacturing SMEs share similar determinants of innovation activities. However, service SMEs rely more on acquired knowledge compared to their manufacturing counterparts.

The relationship between customer participation and innovation performance has been explored in several studies. Chang and Taylor (2016) conducted a meta-analysis that examined the effects of contextual factors on the relationship between customer participation and new product development performance. Their analysis revealed that involving customers in the ideation and launch stages of new product development improves new product financial performance directly, as well as indirectly through accelerated time to market. However, customer participation in the development phase slows down time to market, leading to a deterioration in new product financial performance.

The study by Anzola-Román, Bayona-Sáez, and García-Marco (2018) investigated the influence of internal and externally sourced innovation practices on the likelihood of achieving product and process innovations. Their findings indicated positive effects of internal R&D and externally sourced innovation practices, as well as a positive influence of organizational innovation on the realization of technological innovations.

Understanding the most effective sources of innovative ideas remains a significant challenge in technological innovation management. Criscuolo et al. (2018) examined the effectiveness of different combinations of knowledge

sources for achieving innovative performance. Their study, based on a large-scale sample of UK firms, revealed important differences between product and process innovation, with broader knowledge searches associated with the former.

THE MANAGEMENT OF INNOVATION AND FIRM PERFORMANCE

Innovation is widely recognized as a crucial driver of firm success, contributing to competitive advantage, market growth, and long-term sustainability. As the business landscape becomes increasingly dynamic and complex, organizations must continuously adapt and innovate to stay ahead. Consequently, understanding firm management factors that influence innovation performance has become a topic of great interest for researchers and practitioners alike.

Cohen and Levinthal (1990) highlighted the concept of absorptive capacity, which refers to a firm's ability to acquire, assimilate, and utilize external knowledge to foster innovation. They emphasized that prior knowledge and experiences significantly influence a firm's absorptive capacity. This perspective underscores the importance of leveraging diverse knowledge sources and learning from external information to enhance innovation capabilities. By exploring the relationship between diverse knowledge and innovation outcomes, valuable insights can be gained into how firms can effectively tap into a range of knowledge domains.

While much of the existing literature has primarily focused on product and process innovation, there is a growing recognition of other dimensions of innovation that extend beyond tangible outputs. These dimensions include management, organizational, and social innovations, which encompass novel practices, structures, and techniques that advance organizational goals. OECD/Eurostat (2018) proposed a comprehensive framework encompassing these various innovation types. Acknowledging and exploring these diverse dimensions of innovation contribute to a more comprehensive understanding of the innovation process and its impact on firm performance. Chen, Wang, and Huang (2019) investigated the relationship between organizational innovation and technological innovation capabilities, exploring their impact on firm performance. Through structural equation modeling, their study revealed that innovation capabilities partially mediate the link between organizational innovation and firm performance.

Furthermore, effective innovation management practices play a vital role in realizing the full potential of innovation. Birkinshaw and Mol (2008) identified four key processes—motivation, invention, implementation, and theorization and labeling—that collectively shape management innovation. By examining the roles of change agents within and outside the organization, valuable in-

sights can be gained into how innovation management practices can be optimized to maximize the benefits derived from innovation efforts.

However, despite the recognized importance of innovation and its multidimensional nature, challenges persist in realizing significant economic returns from innovation. Teece (1986) highlighted that profits often accrue to complementary asset owners, customers, and imitators rather than to the original developers of intellectual property. This raises important questions regarding the alignment of innovation strategies with appropriate management practices to ensure that firms capture and capitalize on the economic benefits of their innovative endeavors.

Given the multifaceted and ongoing nature of innovation, it is essential to delve into the literature to gain a comprehensive understanding of the relationship between diverse knowledge and diverse innovation outcomes. By exploring the interplay between absorptive capacity and different dimensions of innovation, in the context of effective innovation management practices, this study aims to provide evidence on the relationship between diverse knowledge and diverse innovation outcomes among Chilean firms. Through this investigation, valuable insights can be obtained to inform firms' innovation strategies and enhance their ability to drive successful innovation outcomes while realizing economic returns.

INFORMATION SOURCES AND INNOVATION

The study of information sources and their impact on firm-level innovation performance is highly motivated by the recognition of innovation as a critical driver of firm success. In today's competitive business environment, firms are constantly seeking ways to improve their innovation capabilities and outcomes. Understanding the role of information sources in this process is essential for firms aiming to leverage knowledge effectively and achieve sustainable innovation performance.

Previous research has shed light on the influence of different types of information sources on innovation. Arvanitis, Lokshin, Mohnen, and Wörter (2013) conducted a study based on panels of Dutch and Swiss innovating firms, finding that both "buying" and "cooperating" have a positive effect on innovation. However, simultaneous utilization of these information sources does not necessarily lead to higher innovation performance. Pejić Bach et al. (2015) emphasized the catalytic role of information sources in innovation improvement, utilizing CIS data from Croatia, France, and the Netherlands. Their findings indicated that internal sources, customers, suppliers, and universities are important information sources for both internal and external R&D activities across the three countries. Interestingly, firms from the Netherlands exhibit different

patterns in utilizing information sources, relying more on competitors compared to firms from Croatia and France. Additionally, government information sources had a relatively smaller impact on firms' innovation performance.

The distinction between internal and external sources of information has been explored in relation to the generation of product and process innovation. Gómez, Salazar, and Vargas (2016) examined the usage of internal and external sources of information by Spanish firms, including customers, suppliers, competitors, consultants, and universities. They found that the importance of external sources of information varies depending on the type of innovation considered. For process innovation, firms mainly rely on suppliers, while for product innovation, the main contribution comes from customers. Damanpour, Sanchez-Henriquez, and Chiu (2018) investigated the dual role of internal and external sources of knowledge and information in the adoption of managerial innovations. Their findings indicated that internal implementation actions have a stronger effect than external implementation actions in influencing innovation adoption. Dotzel and Faggian (2019) analyzed the relationship between external knowledge sourcing and various innovation outcomes in rural and urban establishments in the U.S. Their results suggested that external knowledge sourcing specifically promotes product, process, and green innovation in U.S. firms. They also highlighted the potential importance of knowledge sourcing from non-local organizations, particularly in supporting innovation in rural markets compared to urban markets.

Furthermore, the literature has explored the effects of different combinations of knowledge sources on innovation output. Basit and Medase (2019a) highlighted the positive link between knowledge diversity and firm-level innovation performance, emphasizing the importance of knowledge from customers in the private and public sectors, as well as knowledge from competitors. Basit (2021) extended this research by examining the impact of external knowledge sources on the willingness of small and medium-sized enterprises (SMEs) to introduce organizational innovation, revealing the greater importance of external knowledge for small firms and their propensity to utilize diverse sets of external knowledge.

By delving into the literature on information sources and innovation, it becomes evident that diverse knowledge utilization plays a vital role in driving firm-level innovation performance. The interplay between different types of information sources, whether originating from paid deals or cooperation agreements, and whether derived from internal or external agents, offers valuable insights for firms aiming to enhance their innovation capabilities and achieve superior innovation outcomes. Therefore, this study seeks to contribute to the existing body of knowledge by examining the relationship between diverse knowledge sources and diverse innovation outcomes within the context of

Chilean firms.

ENDOGENEITY OF R&D ON INNOVATION OUTPUTS

Understanding the relationship between research and development (R&D) investment and innovation outputs is crucial for firms aiming to enhance their innovation performance. R&D plays a vital role in driving innovation, but the nature of the interrelation between R&D inputs and innovation outputs is complex and multifaceted. By examining the endogeneity of R&D investment on innovation outputs, researchers seek to disentangle the causal relationship between these variables and provide valuable insights into the effectiveness of R&D strategies in fostering innovation.

Several studies have addressed the endogeneity of R&D investment on innovation outputs using various econometric approaches. Crepon, Duguet, and Mairesse (1998) conducted an analysis at the firm level, focusing on French manufacturing firms. Their study employed a system of simultaneous equations to examine the interplay between productivity, innovation, and R&D. They proposed an econometric method to address selectivity and simultaneity biases, which has subsequently been adopted by numerous researchers using data from different countries.

Piga and Vivarelli (2004) emphasized the connection between R&D investment and the decision to carry out innovations. They employed an empirical approach that enabled a joint analysis of the determinants of these two decisions while correcting for sample selectivity. Their study shed light on the intertwined relationship between R&D investment and innovation activities.

Mairesse and Mohnen (2004) utilized an instrumental variable approach to evaluate the contribution of R&D to innovation. Their research developed a generalized Tobit model based on the notion that firms engaging in R&D are more likely to be selected from those that produce some innovative outcomes. This approach also provided insights into the effectiveness of R&D in driving innovation.

In line with addressing endogeneity and selectivity issues in estimating the effects of R&D on innovation outputs, Basit and Medase (2019b) adopted a binary instrumental variable approach. Their study focused on the relationship between R&D investment and firm-level innovation performance, utilizing microdata from the German Community Innovation Survey 2013. By employing instrumental variable techniques, they were able to overcome potential biases and obtain more reliable estimates of the effects of R&D on innovation outputs.

By exploring the literature on the endogeneity of R&D on innovation outputs, researchers aim to disentangle the complex relationship between these variables. The use of econometric methods, such as simultaneous equation

models, instrumental variable approaches, and correction for sample selectivity, provides valuable insights into the effectiveness of R&D strategies in driving innovation outcomes. These methods also serve as a starting point to study the effects of additional variables such as information sources on innovation outputs.

3. Theoretical Model

To develop the model, this study first considers the relationship between research and development (R&D) and innovation outcomes. It is widely recognized in the literature that R&D is a key determinant of innovation output. Harris and Moffat (2011) highlight that previous studies have provided empirical evidence and justifications for this relationship, considering R&D as an input in the production function of innovation. This notion has been discussed and examined from various perspectives with diverse datasets since Geroski's work in 1990. Building upon Schumpeter's idea that R&D is driven by entrepreneurship with the objective of gaining market power through innovation. Harris and Trainor (1995) empirically analyzed this concept. They proposed that entrepreneurs are the ones who invest in R&D, motivated by the desire to generate innovations.

Mairesse and Mohnen (2002) conducted a preliminary analysis of the first Community Innovation Survey, leading them to conclude that research and innovation activities play a fundamental role in knowledge-based economies. Their findings suggest that new knowledge is a key driver of firm innovation and growth. Furthermore, they highlight the importance of research that integrates innovation and production accounting frameworks in a systematic manner, as it can significantly contribute to understanding the complex relationship between R&D and innovation output.

The theoretical modeling in this study draws upon the idea put forth by Crepon, Duguet, and Mairesse (1998) that innovation output is the result of R&D investment, human capital intensity, variables associated with the market, and information sources. It is important to note that R&D is not assumed to be exogenous but rather partially endogenous, as argued in their paper and supported by other sources in the literature.

Previous studies have shown a positive relationship between human capital intensity, R&D investment, and innovation output. In a recent work, Medase (2019a) suggested that product, process, marketing, and organizational innovation can be attributed to R&D investment and human capital, with different information sources exerting varying effects on different types of innovation outputs. Specifically, Medase (2019b) focused on knowledge flows from cus-

tomers and competitors and found that different innovation information sources influence different categories of innovation.

Building on the existing literature, we propose a basic model wherein innovation is contingent upon R&D investment, human capital, knowledge sources, and various additional moderating and control variables, such as size and economic sector indicators. To comprehensively capture the multifaceted nature of innovation outputs, this study introduces a multinomial model. Within this framework, the determination of innovation output is influenced by R&D investment, human capital intensity, innovation information sources, and a set of control variables. The specific components of the model are outlined as follows:

$$\mathrm{I}_{\mathrm{i}} = \alpha + \mathrm{x}_{\mathrm{i}}\beta_{\mathrm{1}} + \mu_{\mathrm{i}} \tag{1}$$

Where $x_i = \left(R\&D_i, HC_i, OtherInv_i, Emp_i, Inf_i^1, Inf_i^2, Inf_i^3, Act_i^1, \ldots, Act_i^n\right)$

With R_i is R&D investment, $OtherInv_i$ is funding of other innovative investment activities including acquisition of knowledge, machinery and training, HC_i is human capital intensity, Emp_i is the log of the number of employees or a measure of firm size, Inf_i^1 is a dummy indicating whether or not the source of ideas for innovation developed with information from competitors, Inf_i^2 is a dummy indicating whether or not the source of ideas for innovation developed with information from customers, Inf_i^3 is a dummy indicating whether or not the source of ideas for innovation developed with information from government agencies, and $Act_i^1, \ldots, Act_i^n$ are economic sector dummies.

4. Data

The study of innovation determinants and the relationship between firm characteristics, innovation inputs, and innovation outputs, based on innovation survey data and econometric research, has been extensively conducted over the past three decades. Mairesse and Mohnen (2010) provided an overview of the history, evolution, and content of innovation surveys, discussing the characteristics of the data they encompass and the challenges they pose to analysts and econometricians. The authors also documented the two primary purposes for which these data have been utilized: the construction of scoreboards for monitoring innovation and scholarly analysis of various issues related to innovation. A significant portion of the literature employing innovation survey data has focused on examining the determinants, effects, complementarities, and dynamics of innovation.

For the empirical analysis in this study, micro-level data from the Chilean

National Innovation Survey (ENI) 2019-2020 were utilized. The database is made from a probabilistic design (representative of all those companies registered in the Chilean Tax Service (SII) and sales of USD$100,000 per year. The survey comprises a sample of 5,790 firms, which is representative of a universe of 190,084 Chilean firms across all economic sectors, including Manufacturing, Mining, Energy, and Services. The survey has been conducted since 1995, and its questionnaire aligns with the guidelines outlined in the fourth edition of the Oslo Manual OECD/EUROSTAT (2018).

The National Innovation Survey (ENI) aims to provide information on the structure of the innovation process of companies in Chile (inputs and results) and to show the relationships between said process and the innovation strategy of companies, the innovative effort, the factors that influence their ability to innovate and the economic performance of companies.

ENI measures variables such as the type of innovation (product and business processes), degree of novelty, intellectual property rights, innovative activities (including research and development, R&D), carried out by Chilean companies in different economic sectors and regions of the country. The survey also captures information on firm characteristics, sales, exports, employment by education levels, innovation output, information sources, other innovative investments, R&D activities, R&D cooperation, and innovation obstacles. Notably, the Chilean Innovation Survey also captures non-technological innovation, such as marketing, organizational, and social innovation.

The database is structured in thirteen modules that firstly describe product and different kinds of process innovation and their effects at the firm level. It then measures social innovation and different sorts of innovation spending including R&D, though data with the detail of R&D spending and funding is collected in a separate R&D survey. A following section of the survey collects data on information sources and cooperation activities regarding innovation efforts. It also contains a module on human resources dedicated to innovative or innovation related activities, followed by a module that describes whether firms obtained innovation funding from a series of public programs. Finally, the survey structure includes innovation obstacles, intellectual property rights and perspectives for future firm innovation.

Table 1 presents a comprehensive description of the variables employed in this research. The database contains valid information for 5,519 observations. The average firm in the database has a 21% likelihood of achieving at least one type of innovation. Among the various types of innovation, process innovation is the most prevalent, with the average firm having 18% probability of reporting its implementation during the period 2019-2020. Product and organizational innovations follow closely, reported by 10% and 9% of firms, respectively, while social innovations were achieved by only 3% of the sam-

pled firms. Average firms have a 9% probability of investing io R&D during the period, while they are more likely to engage in other innovative investments including machinery, training, and knowledge acquisition. The probability of using information from customers is 8%, followed by government sources, and lastly, competitor sources. On average, 28% of employees possessed a professional degree or higher level of education. Less than 8% of the firms in the sample exported more than USD$500,000, and only 3% of the firms received public funds for innovation activities.

The variable description is summarized on Table 2. All these variables are self-reported and correspond to the survey responses provided by firms' managers. Most of the variables used are binary variables because they express whether the firm has declared to have performed or achieved a specific action over the period 2019-2020. The variable log of the numbers of employees, on the other side is continuous and is intended to reflect the size of the firm.

Table 3 presents the correlation matrix of the main variables. The correlation results demonstrate that firm-level resources, innovation inputs, and innovation output variables exhibit the expected signs. The instrumental variables, high exports, and public innovation funding, exhibit a significantly higher correlation with the instrumented variable R&D activity compared to their correlation with the dependent variables of innovation outputs.

TABLE 1

SUMMARY STATISTICS

Variable	Observations	Mean	Std. Dev.	Min	Max
1. Any Innovation	5519	0,207	0,405	0	1
2. Product Innovation	5519	0,101	0,301	0	1
3. Process Innovation	5519	0,185	0,388	0	1
4. Marketing Innovation	5519	0,061	0,239	0	1
5. Organizational Innovation	5519	0,091	0,288	0	1
6. Social Innovation	5519	0,031	0,174	0	1
7. R&D Activity	5519	0,087	0,282	0	1
8. Other Innovative Investments	5519	0,155	0,362	0	1
9. Source Competitors	5519	0,004	0,067	0	1
10. Source Clients	5519	0,082	0,274	0	1
11. Source Government	5519	0,020	0,140	0	1
12. Highly Educated	5519	0,281	0,328	0	1
13. Log Total Employees	5519	3,100	1,714	0	9,89
14. Exports USD$500.000+	5519	0,076	0,265	0	1
15. Public Inn. Funding	5519	0,034	0,182	0	1

Source: Own calculations based on the Chilean Innovation Survey 2019-2020.

TABLE 2

DESCRIPTION OF VARIABLES

Variable Name	Type	Description
Any innovation	Dummy	1 if the firm introduced any innovation in 2019-2020 and 0 otherwise
Product innovation	Dummy	1 if the firm introduced new or significantly improved product or service in 2019-2020 and 0 otherwise
Process innovation	Dummy	1 if the firm introduced new or significantly improved operational processes in 2019-2020 and 0 otherwise
Marketing innovation	Dummy	1 if the firm introduced marketing innovation (i.e. significant modification in design or packaging of goods or services) in 2019-2020 and 0 otherwise
Organizational innovation	Dummy	1 if the firm introduced organizational innovation (i.e. new business practices for organizing procedures) in 2019-2020 and 0 otherwise
Social innovation	Dummy	1 if the firm introduced social innovation in 2019-2020 (i.e. sustainable innovation) and 0 otherwise
Internal R&D	Dummy	1 if the firm carried out internal R&D activities
Other Innovative Investments	Dummy	1 if the firm carried out investments
Source of knowledge from competitors	Dummy	1 if the firm get information source for new ideas in current innovation projects from the competitors in 2019–2020 and 0 otherwise
Source of knowledge from the customers	Dummy	1 if the firm get information source for new ideas in current innovation projects through the customers sector in 2019–2020 and 0 otherwise
Source of knowledge from the government	Dummy	1 if the firm get information source for new ideas from interaction with government agencies in 2019-2020 and 0 otherwise
Graduate employees	Continuous standardized to 0-1	Number of graduate employees (professional, master or PhD) to the total number of employees in 2020.
Employment	log	The log of the number of employees as a measure of firm size
High Exports	Dummy	1 if exports were higher than USD$500,000 over 2019-2020 and 0 otherwise.
Public Funding	Dummy	1 if firm received innovation funding from the public sector in 2019-2020 and 0 otherwise
$Act_i^1,\ldots,Act_i^{13}$	Dummy	1 if firm belongs to specific sector and 0 otherwise

Source: Variables defined based on data from the Chilean Innovation Survey 2019-2020.

TABLE 3

CORRELATION MATRIX

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Any Innovation	1,00														
2. Product Innovation	0,66	1,00													
3. Process Innovation	0,93	0,51	1,00												
4. Marketing Innovation	0,50	0,37	0,53	1,00											
5. Organizational Innovation	0,62	0,36	0,66	0,52	1,00										
6. Social Innovation	0,32	0,31	0,28	0,22	0,24	1,00									
7. R&D Activity	0,52	0,48	0,46	0,30	0,32	0,31	1,00								
8. Other Innovative Investments	0,76	0,53	0,72	0,40	0,47	0,29	0,46	1,00							
9. Source Competitors	0,12	0,12	0,13	0,11	0,10	0,09	0,17	0,14	1,00						
10. Source Clients	0,54	0,54	0,49	0,41	0,37	0,27	0,49	0,59	0,20	1,00					
11. Source Government	0,25	0,23	0,22	0,16	0,18	0,24	0,31	0,26	0,31	0,29	1,00				
12. Highly Educated	0,12	0,14	0,11	0,07	0,09	0,08	0,12	0,09	0,04	0,10	0,08	1,00			
13. Log Total Employees	0,19	0,13	0,17	0,08	0,14	0,09	0,22	0,18	0,07	0,13	0,08	-0,20	1,00		
14. Exports USD$500.000+	0,12	0,10	0,08	0,06	0,07	0,06	0,19	0,10	0,05	0,10	0,07	0,00	0,33	1,00	
15. Public Inn. Funding	0,22	0,22	0,19	0,10	0,15	0,17	0,32	0,23	0,07	0,19	0,24	0,09	0,04	0,05	1,00

Source: Own calculations based on the Chilean Innovation Survey 2019-2020.

5. Empirical Strategy

To empirically estimate the theoretical model, our first step is to examine the presence of endogeneity related to a selectivity problem. The literature provides several compelling reasons why innovation could also influence R&D, which have been well-documented. Mansfield (1969) presented one of the earliest works on this relationship, arguing that successful innovation increases a firm's technological opportunities, making further innovation efforts more likely.

Another argument for the impact of innovation on R&D is the difficulty firms may face in obtaining funding for innovation projects from external sources due to their inherent riskiness (Peters, 2009). If successful innovations lead to increased profitability and access to external funding, firms are more likely to engage in further R&D.

Furthermore, the relationship between innovation, exporting, and R&D has been discussed as a bidirectional force by Harris and Moffat (2011). Some studies have emphasized the persistence of innovation and its positive impact on subsequent R&D investment. Geroski et al. (1997) and Malerba and Orsenigo (1999) have also explained the mechanism through which innovation influences R&D.

From the literature, it can be concluded that the determinants of R&D expenditure for an individual firm are not completely independent of the firm's probability of innovating. Innovating firms allocate resources to R&D to achieve innovations, while non-innovating firms may invest in R&D to enhance their absorptive capacities. Additionally, the variables that explain R&D may differ depending on whether the firm is innovating or not. Hence, there is a selectivity problem.

To address the selectivity problem, one perspective is to consider innovation as an auto-selection process. Expected R&D investment depends on the firm's innovation status, making the selectivity problem more complex than a simple sample selectivity bias. Kriaa and Karray (2010) suggest that one approach to solving this problem is to limit observed heterogeneity between firms while also controlling for unobserved heterogeneity. Other researchers have used an approach based on Heckman (1979) to address selectivity problems in this model. Following Basit and Medase (2019b), this work adopts an instrumental variable (IV) binary treatment model with a selection equation based on a set of instruments as the empirical methodology.

The econometric model aims to study the relationship between firm-level innovation, human capital, internal R&D activities, and sources of knowledge flows. Given the binary nature of the endogenous and instrumental variables, this study employs an IV binary treatment model. The estimation method is a

two-stage Heckman binary treatment model. This empirical setup allows us to address potential endogeneity problems. The binary treatment model used in this research has been thoroughly explained by Wooldridge (2010) and has been employed by authors such as Basit (2021) and Cerulli (2012). The two-stage Heckman binary treatment model with heterogeneous treatment response helps to address the endogeneity issues that arise in this context, where the relationship between innovation output and performance differs between firms investing in R&D and those that do not.

The specification of the instrumental variable model is as follows:

$$y = \mu_0 + \propto w + x\beta_0 + w\left(x - \mu_x\right)\beta + e_0 + w\left(e_1 - e_0\right) \tag{2}$$

Where we assume that observable and unobservable heterogeneity are not the same, so $\left(e_1 \neq e_0\right)$. Following the principle of the two-stage sample selection estimation of Heckman (1979), we assume that on a binary treatment model we can still observe normality of the error term. This way we use a general model firstly specifying a fundamental regression.

$$y_i = x_i\beta + \mu_{1i} \tag{3}$$

Where selection implies that the dependent variable is known under the condition that

$$z_i\delta + \mu_{2i} > 0$$

Where $\mu_1 \sim N\left(0,\sigma\right),\ \ \mu_2 \sim N\left(0,1\right),\ \ and\ Corr\left(\mu_1,\mu_2\right) = \rho$. And if we could assume that $\rho = 0$, we could ignore the selection problem.

The strategy then implies the estimation of two equations, the main equation with innovation output as dependent variable, and a selection equation with R&D dummy as a dependent variable. Innovation output is a set of dummy variables that can describe each type of innovation separately with:

$$INN_i = \alpha + x_i\beta_1 + R\,\&\,D_i\beta_2 + \mu_i \tag{4}$$

where: $x_i = \left(InnAct_i, Inf_i^1, Inf_i^2, Inf_i^3, HC_i, Emp_i, Act_i^1, \ldots, Act_i^n\right)$, and:

$$R\,\&\,D_i = \delta_1 + x_i\delta_1 + z_i\delta_2 + \mu_i \tag{5}$$

where: $$z_i = \left(HExp_i, PublicFunding_{i,}\right)$$

Where $InnAct_i$ is a dummy with value 1 if the firm has spent on any of the other non-R&D activities: machinery, knowledge acquisition, training. Inf_i^1

is a dummy indicating whether the source of ideas for innovation developed with information from competitors, Inf_i^2 is a dummy indicating whether the source of ideas for innovation developed with information from customers, Inf_i^3 is a dummy of whether the ideas for innovations came from government sources. HC_i is human capital intensity measured as highly educated employees divided by total employees, Emp_i is the log of the number of employees as a measure of firm size. $Act_i^1,\ldots,Act_i^n$ are economic sector dummies. For the first stage equation the instrumented variable $R\&D_i$ is a dummy equal to 1 if the firm has done R&D investment. We used two instruments that are statistically valid with significantly higher correlation to the instrumented variable compared to the endogenous variable[1]. The instruments are $HExp_i$ that is a dummy indicating whether exports were higher than USD$500,000, and $PublicFunding_{i,}$ that is a dummy equal to 1 if the firm received any kind of public funding for innovation during the period 2019-2020, and 0 otherwise. The instruments were chosen considering that both, access to exporting markets and access innovation public funding, are expected to have a greater impact over R&D efforts compared to innovation outputs because the latter result from a more complex knowledge generation processes that is affected by innovation efforts, information sources and firms' human capital.

6. Main Results

The findings of this paper are presented in this section. The estimation method begins with a set of preliminary binary probit regressions using 5,519 observations. This step is taken before considering any endogeneity problems.

Table 4 displays plausible results that align with the theoretical model. All types of innovation outputs considered in the model are positively and significantly influenced by both R&D investment and other innovative investments. The proportion of employees with a professional title or higher level of education also has a positive and significant impact on innovation output in all regressions. Firm size, measured as the logarithm of total employees, consistently shows a positive parameter in all regressions, although its impact appears to be lower compared to the other variables. Furthermore, firm size has a significant impact on process, organizational, and social innovation, but its significance is not observed in the case of product and marketing innovation. This preliminary result suggests that smaller firms may have the ability to achieve these types of innovation output without facing clear disadvantages due to their size.

[1] See the correlation details on table 3

Based on these initial results, there is evidence that information from competitors may have very little or no impact on all types of innovation output. This result could be due to biases caused by endogeneity problems. It could also be attributed to the fact that a relatively small percentage of firms utilize information from competitors. Regarding sourcing innovation information from customers, the results indicate that it is an important and significant variable that positively affects all types of innovation outputs. This finding suggests that firms attach greater importance to customer feedback, indicating that customer-oriented firms are more likely to succeed in their innovative endeavors. This observation aligns with recent management literature that emphasizes the importance of focusing business models on customers. The regressions also reveal that sourcing information from government agencies is associated with specific types of innovation outputs. The results propose that government information has a significant impact only in the case of social innovations.

However, following our empirical strategy and in line with previous literature[2] on the estimation of innovation determinants, Table 5 examines the same question using a Heckman two-stage binary instrumental variable treatment model. This estimation method has been employed in other papers, including Basit and Medase (2019a, 2019b). The binary selection variable is R&D activity, and we use dummy variables as instruments to indicate whether exports exceed USD$500,000 and whether any public funding for innovation was received. Both instruments exhibit considerably higher correlation with the R&D activity dummy compared to innovation output variables. Like on the previous regressions, control variables for economic sector are included but not reported in the table.

First stage results are reported on the first column. Note that the first-stage equation is the same for all six innovation equations. We find that both instruments, exports and public funding have a positive and significant impact on R&D efforts at the firm level.

The results of the following columns suggest that innovative investments other than R&D is also a significant determinant of all types of innovation. The previous finding indicating a low and insignificant impact of information from competitors on innovation output is also supported by these results. Information from clients as a source for innovation ideas has a positive and significant effect in all cases except for social innovation, where government agencies emerge as the only important and significant information source. Government information also has a positive and significant impact on process and organizational innovation, albeit with smaller parameter sizes. The positive effect of the proportion of highly educated employees on different types of innovation

[2] The argumento f why R&D should be considered endogenous on an Innovation equation is particularly well explaiden in the work by Crepon, Duguet and Mairesse (1998).

output is observed, although the effect is smaller than what was observed in the previous table and is not significant in the case of social innovation. The results also demonstrate that the logarithm of the total number of employees has a positive and significant impact on innovation outputs, except in the case of product and marketing innovation, which is consistent with the findings from the previous table.

For each of the second stage equations, the two-stage Heckman model estimates rho (actually, the inverse hyperbolic tangent of rho) that represents the correlation of the residuals in the two equations. Additionally, it presents the estimation of sigma (actually, the log of sigma) which represents the standard error of the residuals of the second stage equation. Lambda is rho*sigma, which is found to be significant on all but one of the equations which suggests that the estimation of R&D in the first equation is relevant for the estimation of the second stage equations for all kinds of innovation output except organizational innovation.

These results are relevant because, based on a previously validated empirical strategy[3] that takes endogeneity into account, they explain the importance of different information sources for the several distinct types of innovation outputs. The results show some similarity with previous works[4] regarding the importance of customer information for innovation output but also differ finding that for the case Chilean firms the importance of information from competitors is not an important determinant for innovation output. It could be the case that this result is observed because Chilean firms have a very low probability of sourcing innovation information from competitors, and hence there is not enough variation to find a significant parameter. In fact, only 0.4% of firms declared to have used information from competitors as a source of innovation ideas. Additionally, it could also be the case that the low use of competitor information is the result of low trust or higher levels of secrecy among industry-level competitors. In any case, this result calls for further research that can dig into industry-level information flows to explain this low frequency and low impact firm competitor relation.

But even though information from competitors has not proven to be relevant for innovation output, we found that innovation output among Chilean firms is driven to a large extent by market orientation, particularly by sourcing information from customers. In the line with the findings by Anzola-Román (2018), this result is important from a managerial point of view because it shows that considering customer data is an important driver of innovation success. Additionally, from the public policy perspective, this result implies the opportunity of developing public instruments to promote customer-firm inter-

3 Heckman (1979)

4 Basit and Medase (2019a, 2019b).

actions such as experimental fairs or targeted consumer surveys.

But the most relevant and novel result found on this work is related to the estimation of social innovation determinants. The work by Tortia et al (2020) discussed how social innovation interplays with entrepreneurship in public and private institutions. Social innovations imply the achievement of results that benefit socially vulnerable groups or the enviroment, it should be financially sustainable, and it functions based on the use of new approaches and ideas to solve a particular social problem.

We find that in terms of information sources, social innovation is mainly driven by information from government institutions, while customer and competitor sources are not relevant when the full model is estimated. This result, if confirmed by further research, could have important public policy implications. The work by Mulgan (2007) discussed that social innovation often involves universities, government agencies and private companies working together. He also showed that social innovation is more related to the combination of knowledge from different actors rather than the advancement of new technologies at the individual organizational level. Particularly, considering that social innovation has a large positive externality component, our results suggest that public funding instruments to promote collaboration with government institutions could help promote innovations that have the highest social value.

TABLE 4

PRELIMINARY BINARY PROBIT REGRESSION

	Any Innovation	Product Innovation	Process Innovation	Marketing Innovation	Organizational Innovation	Social Innovation
R&D Activity	1.313	0.863	0.798	0.412	0.406	0.666
	(0.106)**	(0.081)**	(0.086)**	(0.089)**	(0.080)**	(0.100)**
Innovation Activity	2.397	1.183	2.125	1.062	1.240	0.806
	(0.078)**	(0.071)**	(0.069)**	(0.080)**	(0.069)**	(0.097)**
Source Competitors	-0.403	-0.381	0.216	0.089	-0.111	-0.349
	(0.495)	(0.283)	(0.405)	(0.282)	(0.268)	(0.301)
Source Clients	0.586	0.868	0.296	0.676	0.378	0.296
	(0.120)**	(0.084)**	(0.094)**	(0.090)**	(0.083)**	(0.105)**
Source Government	0.152	0.048	-0.024	0.105	0.151	0.573
	(0.214)	(0.143)	(0.163)	(0.149)	(0.137)	(0.146)**
Highly Educated	0.412	0.439	0.390	0.307	0.383	0.349
	(0.095)**	(0.109)**	(0.092)**	(0.118)**	(0.101)**	(0.147)*
Total Employees	0.062	0.029	0.059	0.010	0.077	0.066
	(0.017)**	(0.019)	(0.016)**	(0.021)	(0.018)**	(0.025)**
Constant	-1.760	-2.097	-1.768	-1.818	-2.244	-2.093
	(0.171)**	(0.197)**	(0.168)**	(0.183)**	(0.195)**	(0.203)**
N	5519	5519	5519	5519	5519	5519

* p<0.05; ** p<0.01

Source: Own calculations based on the Chilean Innovation Survey 2019-2020.

TABLE 5

BINARY TWO-STAGE HECKMAN INSTRUMENTAL VARIABLE REGRESSION

	1st Stage R&D Activity	Any Innovation	Product Innovation	Process Innovation	Marketing Innovation	Organizational Innovation	Social Innovation
Innovation Activity	0.941	0.758	0.212	0.731	0.165	0.279	0.048
	(0.074)**	(0.014)**	(0.013)**	(0.015)**	(0.012)**	(0.014)**	(0.009)**
Source Competitors	0.117	-0.054	-0.084	0.068	0.060	0.016	-0.037
	(0.323)	(0.059)	(0.051)	(0.061)	(0.046)	(0.054)	(0.035)
Source Clients	0.997	0.250	0.271	0.218	0.230	0.129	0.015
	(0.083)**	(0.021)**	(0.019)**	(0.022)**	(0.017)**	(0.020)**	(0.013)
Source Government	0.575	0.143	0.012	0.113	0.044	0.058	0.138
	(0.145)**	(0.031)**	(0.027)	(0.032)**	(0.024)	(0.029)*	(0.019)**
Highly Educated	0.792	0.093	0.040	0.091	0.037	0.043	0.008
	(0.123)**	(0.014)**	(0.012)**	(0.014)**	(0.011)**	(0.013)**	(0.008)
Total Employees	0.203	0.019	-0.000	0.019	0.003	0.010	0.000
	(0.021)**	(0.003)**	(0.002)	(0.003)**	(0.002)	(0.002)**	(0.002)
Exports USD$500.000+	0.348						
	(0.098)**						
Public Inn. Funding	1.080						
	(0.116)**						
R&D Activity		-0.177	0.295	-0.272	-0.041	0.051	0.198
		(0.041)**	(0.039)**	(0.043)**	(0.035)	(0.042)	(0.027)**
Constant	-3.162	0.002	0.019	-0.003	0.044	-0.017	0.052
	(0.239)**	(0.024)	(0.021)	(0.026)	(0.019)*	(0.023)	(0.015)**
	5519	5519	5519	5519	5519	5519	5519
lambda		0.265	0.022	0.277	0.063	0.026	-0.055
		(0.022)**	(0.021)**	(0.023)**	(0.019)**	(0.023)	(0.015)**
Rho		0.962	-0.096	0.962	0.281	0.054	-0.395
Sigma		0.275	0.236	0.287	0.215	0.252	0.165

* p<0.05; ** p<0.01

Source: Own calculations based on the Chilean Innovation Survey 2019-2020.

7. Concluding Remarks

Innovation is widely recognized as a key driver of economic growth and competitiveness. As societies and economies become increasingly complex, firms' ability to adapt and innovate becomes paramount. This study aimed to shed light on the factors that contribute to successful innovation by examining the impact of diverse knowledge sources on different types of innovation outputs. By leveraging reliable innovation survey data from Chilean firms, we have made significant contribution to the understanding of innovation dynamics in emerging economies.

To consolidate our understanding of the role of external knowledge sources in enhancing firms' innovative performance, our study investigates the effects of sourcing knowledge from various external actors. We studied the importance of knowledge from customers, competitors, and public institutions over product, process, marketing, organizational and social innovation outputs.

Several other works have evaluated this relation before in different contexts. The study by Medase and Basit (2019a) studied the impact of different knowledge sources on different types of innovation outcomes among German firms. Previous studies had focused of the relation between information from customers and product innovation (Tsai, 2009 and Vega-Jurado et al., 2009). Much of the previous literature on this topic follows the idea of the absorptive capacity described by Cohen et al., (2002) and focuses on manufacturing firms while this research was able to use data from primary, secondary, and tertiary sectors.

Most of the work in the literature including Ahrweiler (2011), Basit and Medase (2019a, 2019b), has found positive effects of external knowledge on innovation performance. But when considering the impact of external knowledge on innovation performance some care must be exercised. The work by Frickel (2011) shown that external knowledge can also have adverse effects that should be adequately managed by firms for incoming information to benefit innovation performance overall. Under specific circumstances, negative effects of information sources have been mentioned by authors and must be taken into consideration by firm decision makers, especially in the presence of multiple innovation information sources (see Barge-Gil, 2010; Grimpe and Sofka, 2009; Hurmelinna-Laukkanen, 2011).

Our findings underscore the importance of external knowledge sources in driving innovation outcomes. Information sourced from customers emerges as a critical factor, positively influencing most types of innovation. This highlights the significance of customer feedback and the need for firms to adopt customer-centric approaches in their innovation processes. The results align with recent management literature emphasizing the central role of customers

in shaping successful business models.

Interestingly, information from competitors demonstrates limited or no impact on innovation output across all types. This challenges the notion that firms can derive substantial benefits from competitor knowledge alone. While this finding may be influenced by endogeneity concerns or a low uptake of competitor information, it suggests that firms should explore alternative knowledge sources beyond their immediate competitors to foster innovation. Recent work by Basit and Medase (2019b) had previously found that knowledge sources from competitors have a significant negative relationship with innovation activities. Our work has shown that this relation is not significant for the case of the Chilean firms. It is therefore reasonable to think that there may be at least no positive impact of sourcing innovation ideas from competitors.

Government information emerges as a valuable resource, particularly for social innovation. It also exhibits positive effects on process and organizational innovations, albeit with smaller magnitudes. These findings underscore the potential role of government agencies in facilitating innovation activities, especially in areas of social importance. Policymakers can leverage these insights to design effective policies that encourage collaboration between firms and government entities, fostering innovation in targeted domains.

While our results indicate that external knowledge from customers and government can foster innovative performance, our results also confirm that R&D, innovation spending, human capital and firm size remain strong determinants of innovation success, as proposed in the literature that follows Crepon, Duguet and Mairesse (1998).

Moreover, our study highlights the significance of other innovative investment beyond traditional R&D. Such investments have emerged as a significant determinant of all types of innovation outputs, emphasizing the need for firms to adopt a holistic approach that encompasses diverse innovation initiatives. This finding suggests that firms can enhance their innovation performance by leveraging various avenues for knowledge acquisition and exploration, beyond R&D investments alone.

The results also indicate that firm size plays a nuanced role in innovation outcomes. While smaller firms can achieve certain types of innovation outputs without clear disadvantages due to their size, the impact of firm size on process and organizational innovations is relatively lower compared to other variables. This implies that innovation success is not always determined by firm size and that smaller firms can effectively compete in specific domains of innovation.

This study investigated the combination of the external sources of knowledge flows, the proportion of graduate employees, innovation expenditure, firm size, and internal R&D to find how these variables impact the likelihood of innovation success measured by five types of different innovation outputs. This

paper contributes to the discussion on the significance of external knowledge to the performance of the innovative firms in the context of the Chilean economy. One important novelty of this work was to identify the determinants of social innovation among Chilean firms. This analysis showed that social innovation is affected differently by the same innovation determinant variables. Particularly, we discovered that the most important determinant of social innovation is sourcing innovation ideas from government institutions. We have also considered the endogeneity present on the model and have addressed it with a proven empirical strategy using instruments that are statistically valid. This work was based on the idea that firms are not self-reliant regarding information resources and that they require to add information and ideas from other firms and institutions to better perform on their innovation outcomes.

By providing a comprehensive analysis of the relationships between information sources and innovation outputs, this research contributes to the existing literature and informs strategic decision-making processes in both the public and private sectors. Policymakers can utilize these findings to design targeted policies that foster specific types of innovation, thereby driving local economies forward. Additionally, firms can leverage these insights to develop innovation strategies that capitalize on diverse knowledge sources, empowering them to stay competitive in a rapidly evolving landscape. From the perspective of managers, it is important to decide which origin of knowledge fits best for a particular firm´s objectives. Considering, for example, that public sources increase the likelihood of social innovation while customer sources are related to more product and process innovations.

While this study sheds light on the unique context of Chilean firms. The analysis could also be extended to the comparison of data from different countries across a common period, to learn of differences that could arise between varied economies. Further investigation is also needed to delve deeper into the mechanisms through which diverse knowledge sources influence innovation outcomes. Such research will contribute to a more comprehensive understanding of innovation dynamics and aid in the formulation of evidence-based policies that stimulate innovation-driven growth.

Moreover, we find that more research is needed to discuss to what extent information sources relate to different innovation outputs depending on characteristics of the sector, and some of the firm's internal capabilities. Future research should also try to use databases that include a panel of the same group of firms. In this research we used cross-section data, and our findings are limited the frame of the data set. A panel would also allow to identify longer term effects of the explanatory variables which would certainly be an interesting question to ask.

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