# How do Firms Innovate in Latin America?

## Identification of Innovation Strategies and Their Main Adoption Determinants

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Institutions for Development Sector

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## Abstract[*]

The study of innovation in Latin American firms has concentrated almost exclusively on the determinants and impacts of innovation investments and outputs. Less attention has been paid to how firms innovate. This study applies factor and cluster analysis to a unique dataset of harmonized innovation surveys from Argentina, Chile, Colombia, Ecuador, El Salvador, Paraguay, Peru, and Uruguay, to identify the main innovation practices and strategies performed by Latin American firms. Three of the four identified innovation strategies can be linked to results from similar studies using European firm-level data. However, none of these strategies resembles a strong science or research orientation. An approach to "open management" innovation emerges as idiosyncratic for Latin American firms. These innovation strategies are associated with differences in sales growth and labor productivity. The analysis also shows that firm resources and capabilities drive innovation strategy selection.

JEL classification: L20, O12, O14, O30, O32, O33, O54

Keywords: innovation, innovation strategy, innovation survey, Latin America

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## 1. Introduction

Latin American firms innovate at least as much as businesses from wealthier nations, as international indicators show (Crespi et al., 2010; UNESCO-UIS, 2017). Nevertheless, firm performance remains far behind the technological frontier (IDB, 2014). This apparent contradiction of high innovation and low performance suggests that some of the clues to solve this puzzle may rely on understanding how Latin American firms are innovating. This work follows a data-driven approach to identify the main innovation strategies performed by Latin American firms, linking them to performance and their main determinants of implementation. The results show a lack of scientific and research activities compared to European firms' innovation strategies and the presence of an idiosyncratic strategy that I have labeled "open management," which stands out in terms of labor productivity compared to other innovative firms. Indeed, two of the other identified strategies labeled as "production improvement" and "product-oriented" are associated only with higher sales growth when comparing to "opportunistic" innovative firms, the fourth identified strategy. Firm capabilities strongly determine strategy selection.

The positive relationship between innovation and firm performance holds for various regions of the world, including Latin America (OECD, 2009). The issue has been studied in this region, mainly by looking at how much firms invest in innovation (Crespi and Zuñiga, 2012; Navarro et al., 2016; Raffo et al., 2008). Less attention has been paid to how firms innovate. The way firms engage in innovation is of great importance. Different innovation strategies not only lead to differences in firm performance and the generation of spillovers. The constraints that innovative firms may face are also different, which in the end, are features that underlie innovation policy (Bruneel et al., 2010; Crespi et al., 2020; Roud, 2018).

An extensive body of literature has found that research and development (R&D) investments are critical determinants of productivity growth (Crepon et al., 1998; Griffith et al., 2006; Lööf and Heshmati, 2006; OECD, 2009). However, Gault (2010) emphasizes that (i) most companies rely on non-R&D activities for innovation and (ii) a significant share of R&D expenditures are made by very few companies. Furthermore, it is a stylized fact that Latin American firms invest significantly less in R&D than in, for instance, the rest of the members of the Organisation for Economic Co-operation and Development (OECD) (Crespi et al., 2021, 2010; UNESCO-UIS, 2017). Hence, although relevant to understand sources of underperformance in private sector development, understanding innovation in Latin American firms implies looking at more activities than in-house technology development.

Some scholars have argued that the adoption of externally developed technologies drives the type of innovation performed in so-called *developing countries* and that local conditions, the availability of resources, and domestic capabilities largely determine the speed of this process (Lall, 1992). The type of economic activity performed by a firm can also narrow or broaden the possibilities of its technological development. The view of technological regimes and Sectoral Systems of Innovation (SSI) consider that characteristics of each economic activity define technological opportunities for the firm and the subset of local actors with which the firm may interact in their innovation process (Castellacci, 2008; Malerba, 2002; Pavitt, 1984).

The result of these conditions would be expressed in how firms innovate. The literature is rich in approaches that distinguish firms that rely on making or buying technology (Veugelers and Cassiman, 1999), performing activities in closed or collaborative manners (Veugelers, 1997), even analyzing the type of partner (Belderbos et al., 2004a), or developing multivariate approaches to define innovation modes, such as Science, Technology, and Innovation (STI), and Doing, Using and Interacting (DUI) (Jensen et al., 2007).

In contrast, in this work, I follow a data-driven approach to identify innovation strategies, in the line of Frenz and Lambert (2009), Leiponen and Drejer (2007), and Srholec and Verspagen

(2012), who have worked with firm-level data from the Community Innovation Survey. Using LAIS, a unique dataset of microdata from Innovation Surveys from several Latin American countries (Crespi et al., 2022), I perform a factor analysis to identify the predominant innovation practices among innovative firms. After this stage, I conduct a cluster analysis to identify a distinct group of firms performing a similar combination of innovation practices. These combinations represent the innovation strategies.

I identify four main innovation strategies in the region, of which three share similarities with strategies found in research using European firm data. However, two crucial differences arise. First, in Latin America, no strategy is characterized by strong ties with scientific or research activities. Second, there is an innovation strategy in Latin America, open management, which cannot be directly linked to those identified in Europe. These innovation strategies are correlated with firm performance in terms of sales growth and sales per employee. Also, observable characteristics of the firm are related to different innovation strategies.

These findings suggest a higher variability of approaches to innovation than that which is typically considered by policymakers in the region. Programs promoting innovation are usually concentrated in technological aspects of innovation projects or solely in R&D. However, my findings suggest that firms in the region would benefit from programs with broader definitions of eligible innovation projects and types of activities that can be supported, in line with the open management innovation strategy. The importance of an innovation strategy oriented toward managerial innovation provides a complementary approach to the interpretations of technological progress in the region, especially those emphasizing its incremental and adopter nature.

The paper is structured as follows. Section 2 provides a brief review of the literature studying how firms innovate from different perspectives. Section 3 describes the dataset and the methodological approach that I have applied to identify the innovation strategies. Section 4 presents and discusses the main innovation strategies identified, the relationship between innovation strategies and firm performance, and the relationship between observable firm characteristics and strategy selection. Finally, Section 5 concludes.

## 2. Background

### 2.1. The Way Firms Innovate and its Effect on Performance

The study of innovation in firms has traditionally focused on R&D activities. Beyond the study of its determinants and impacts, several scholars have analyzed how the different ways R&D activities are conducted influence firm performance. Perhaps the most popular approach has been the study of R&D cooperation. Collaborative R&D allows firms to share financial and technical risks and increase efficiency and spillover gains, but it also increases the likelihood of unwanted knowledge leakages. The empirical evidence shows benefits from engaging in R&D cooperation. Veugelers (1997) finds that Belgian companies that engage in cooperative R&D invest more intensively in R&D. Becker and Dietz (2004) find similar results in the German manufacturing sector. On top of that, the authors also find that joint R&D increases the likelihood of developing new products. Belderbos et al. (2004b) extend the analysis of cooperation in R&D by separating different types of partners. They find that cooperation with competitors and suppliers increases labor productivity, while partnerships with universities were associated with higher levels of innovative sales. Arvanitis et al. (2015) analyze strategies of R&D performing firms, searching for complementarities between cooperating in R&D and subcontracting R&D. Using panel data from the Netherlands and Switzerland, the study finds that R&D performers benefit from cooperation and subcontracting. However, there is no sign of additional gains from engaging in both external R&D activities simultaneously.

Gault (2010) emphasizes that only a small subset of innovative firms performs R&D. A broader set of activities needs to be considered to describe innovation strategies fully. A more general classification of the study of how firms innovate separates the development of new technologies through R&D (Make) and the acquisition of technology embedded in other capital goods and intangibles (Buy). Cassiman and Veugelers (2006) use this distinction in Belgian firms, finding that firms conducting both activities (Make&Buy) have higher innovative performance than the rest of innovative firms. In a cross-country study, Hou and Mohnen (2013) find that the Buy strategy leads to productivity increases in firms from low-income countries, while in middle-income countries, the combination of Make and Buy drives higher economic performance. Denicolai et al. (2016) show that the time dimension also matters. They analyze top European companies and show that in the short term more benefits can be gained from buying technologies, while in the long-term, internal R&D capacities determine performance. Similarly, Pellegrino et al. (2012) find that the acquisition of external technologies (Buy) is the central innovation input for young companies in Italy.

Besides investments and partnerships, other firm actions are part of its innovation strategy. For instance, the use of specific sources of information, financing, or methods to protect their intellectual property also characterize firms' approach to innovation. Jensen et al. (2007) use this notion to define two innovation modes: Science, Technology, and Innovation (STI) and Doing, Using, and Interacting (DUI). Using Danish data, the authors find that firms that combine both modes are more innovative than those exclusively relying on only one of them. Parrilli and Alcalde-Heras (2016) also find complementarity while studying the impact of these innovation modes in the Basque Country in Spain. In this same study, the authors find that the STI mode tends to be associated with product and process innovations, while DUI is related to organizational and marketing innovations. By contrast, in Belarus, the DUI mode is more related to product innovation than the STI mode (Apanasovich, Alcalde-Heras, and Perrilli, 2016).

The open innovation (OI) strategy (Chesbrough, 2003) contains many of the elements previously discussed. In brief, the OI considers a combination of innovative practices related to inbound and outbound innovation activities. In the former, firms can use external sources of information (sourcing) and acquire knowledge produced by others (acquiring). In the latter, firms may sell or license their knowledge (selling) or reveal it to the economy (revealing) (Dahlander and Gann, 2010). The intensity and degree of use of each practice determine the (open) innovation strategy. Parida et al. (2012), analyzing high-tech Swedish SMEs, show that external sources of information are related to incremental innovation and the acquisition of technologies to radical innovations. Hung and Chou (2013) find that the acquisition of technologies complements substantial investments in internal R&D in manufacturing firms in Taiwan.

In Latin America, the study of innovation strategies in firms has been relatively neglected. The work of Katz (1987) was one of the first studies that addressed how Latin American firms engage in innovation. This large-scale research involved a team of economists and engineers who studied the nature and determinants of technological change in firms from major Latin American economies. The idea of innovation modes based on the acquisition of embodied technology and the subsequent adaptation to the local environment has been prevalent in the discussions about technical change in this region. Most of the subsequent quantitative studies have been focused on answering questions about the determinants of innovation and how much resources those firms invest. Benavente (2006), Crespi and Zuñiga (2012), and Raffo et al. (2008), among others, highlight the relevance of going beyond R&D to understand innovation in Latin American firms better. Among the few studies addressing the effects of how firms innovate, Zuñiga and Crespi (2013) follow the Make/Buy approach to study the impact of innovation strategies on employment in Argentina, Chile, and Uruguay, finding that firms following a Make strategy were creating more employment than those performing Make&Buy, and Buy strategies. Using the same classification of innovation strategies, Goedhuys and

Veugelers (2012) show that Buy and Make&Buy are the strategies that lead to higher performance in Brazilian firms.

## 2.2. Identifying Innovation Strategies

Most of the ways firms use to innovate mentioned so far describe the innovation process as a combination of inputs that eventually will produce an innovation output as if the desired outcome were not part of the decision to invest in innovation. However, the selection of innovation inputs by the firm may be determined by the projected (at the time of the decision to invest) innovation output. Indeed, some scholars have considered the innovation output as a feature of the firm's innovation strategy. "Output-based innovation modes" (OECD, 2009; Roud, 2018) use variables describing the innovation effort and scope of the innovation output to define five modes: international innovators, domestic innovators, international modifiers, domestic modifiers, and adopters. On the same line, but applying a different classification technique, Hollenstein (2003) finds five innovation strategies in the Swiss services sector: (i) science-based high-tech firms with full network integration, (ii) IT-oriented network-integrated developers, (iii) market-oriented incremental innovators with weak external links, (iv) cost-oriented process innovators with strong external links along the value chain, and (v) low-profile innovators with hardly any external links. Only strategy (ii) tends to be associated with superior labor productivity and only (iv) with sales growth. The work by Hollenstein (2003) has been influential on how to measure innovation strategies. In general, this family of studies relies on obtaining innovation practices by applying factor analysis to a set of innovation survey-like variables, followed by cluster analysis techniques applied over the innovation practices found, to obtain the combinations of practices that define innovation modes or strategies.[1]

Following this approach, Leiponen and Drejer (2007) identified five innovation modes in Denmark and Finland. Three of these were common in both countries: production intensive, scale/science based, and market driven. On the other hand, supplier dominated and ad hoc innovators were idiosyncratic in Denmark, and incremental innovators and weak/market driven in Finland. Frenz and Lambert (2009) analyzed a more extensive set of countries with a similar methodology.[2] However, the focus of their analysis was at the innovation practice level, not strategies as such. They found common patterns of innovation practices across the countries of the sample, but the relationship between innovation practices and labor productivity was highly heterogeneous. In contrast to the previous studies mentioned in this subsection, which applied quantitative methods to the sample of each country separately, Srholec and Verspagen (2012) performed the analysis using all firm-level data from a sample of European countries. They identified five innovation strategies: high-profile, user-driven, externally-sourced, opportunistic, and low-profile. The main result of their analysis shows that the firm's attributes are highly more relevant to innovation strategy selection than the firm's environment (country and industry conditions).

## 2.3. Determinants of Innovation Strategy

Alternatively, some scholars have argued that the primary determinants of how firms innovate are found at the country level. Framework conditions would facilitate or limit the innovation choices a firm has, set by the availability of resources and the economic environment. In this view, while in some countries, growth is driven by well-suited framework conditions which allow capable firms to produce new-to-the-world technologies, in others, conditions for the adoption and incremental improvements of those technologies are what would lead to economic progress (at least in the short and medium term). On that line, while Lundvall (1992) developed the National Systems of Innovation (NSI) framework, paying particular attention to within-

[1] I define an innovation strategy as a combination of innovation practices. In football (soccer in the United States), for instance, while "counter-attacking" is a strategy, two practices of this strategy would be "defending deep" and "play long balls forward."

[2] Austria, Brazil, Canada, Denmark, France, Korea, New Zealand, Norway, and United Kingdom.

country linkages and conditions that affect the development of new technologies in 'core' economies, Bell and Pavitt (1992) and Lall (1992) highlighted the relevance of country settings in shaping firms' capacity to select and adopt new technologies in 'peripheral' countries. Similarly, Viotti (2002) suggests that peripheral countries should set National Learning Systems to activate learning processes in firms, facilitating the adoption of (foreign) superior technologies.

The literature review by Zanello et al. (2016) finds several country conditions, including education, infrastructure, and the political, legal, and financial system, affecting both the creation and adoption of technologies in less-developed/low-income countries.[3] However, quantitative evidence accounting for differences in innovation strategy adoption between countries is scarce. Among the few studies addressing related issues, Srholec (2011) findes considerable country effects in firms' likelihood to innovate in the set of countries in the Productivity and Investment Climate Survey sample.[4] Mohnen et al. (2006) developed a model that allows them to estimate, after controlling by firm characteristics and economic structure, significant differences in innovation performance among seven European countries.[5] More specifically on the subject of strategies, Srholec (2015), with data from 15 European economies, shows that country characteristics may explain up to 6 percent of the likelihood of firms to engage in innovation cooperation with domestic partners and between 23 and 26 percent of the cooperation with foreign partners.

Theoretical and empirical evidence also points out that the sector's characteristics where the firm operates influence their approach to innovation. Pavitt (1984) defined sectors according to their technological regime as 'science based,' 'production intensive,' and 'supplier dominated.' Evangelista (2000) and Castellacci (2008) continued this line of research by identifying and updating modes of innovation prevalent in economic sectors. According to this view, each sector faces different technological opportunities, which define sectoral trajectories and technological regimes. In other words, the nature of production is critical to define how firms engage in innovation and the practices they need to succeed. The SSI approach expands the sectoral view, underscoring the importance of the interaction between specific sets of agents in each sector (Malerba, 2002). Love and Roper (1999) confirm the importance of economic sectors in innovation decisions. The authors study R&D, technology transfer, and networking intensities, finding that sector-level intensities influence plant-level innovation decisions in the United Kingdom. Sectoral research intensity also affects firms' collaboration with universities in Austria (Schartinger et al., 2002) and Belgium (Veugelers and Cassiman, 2005). In Brazil, sector characteristics strongly affect R&D university-industry cooperation. Indeed, while in most of the Brazilian economy, cooperative R&D with universities tends to substitute internal capacities, there are eight 'outlier' sectors where internal R&D is complemented by cooperation with universities (de Moraes Silva et al., 2017).

Another strand of literature has concentrated on understanding the firms' characteristics that affect innovation strategy adoption. Among these, the concept of absorptive capacities and the resource-based view of the firm may summarize the notion that the scope and intensity of the firm's innovation efforts are critically dependent on its capabilities (Cohen and Levinthal, 1990; Wernerfelt, 1984). Each firm builds its competitive advantages based on its endowments, establishing practices that would be hard to imitate. Conditioned by these capabilities, the firm can learn and improve its performance. However, although idiosyncratic to the firm, dynamic practices are relatively homogenous, identifiable, and shared among a large number of companies (Eisenhardt and Martin, 2000). The premise that the firm's resources determine the source of competitive advantages has been expanded to include assets and organizations beyond the walls of the company by the OI strategy (Chesbrough, 2003). The management of

[3] The authors provide a list of countries considered in these categories.
[4] Conducted between 2002 and 2007.
[5] Belgium, Denmark, Ireland, Germany, the Netherlands, Norway, and Italy.

these external resources includes using external sources of knowledge to fuel the innovation process (inbound open innovation) and exploiting new products through third parties (outbound open innovation) (Alexy and Dahlander, 2014).

Veugelers and Cassiman (1999) found that innovation strategy selection (Make/Buy) depends on the size and resources of the firms, which are also strong determinants of R&D collaboration with universities (Veugelers and Cassiman, 2005). Evidence from manufacturing firms from Spain shows that higher absorptive capacities are related to a higher likelihood of engaging in cooperative R&D (Bayona et al., 2001). However, firm capabilities do not affect all types of R&D collaborations equally. In the Netherlands, large companies are more prone to collaborative R&D, but they are more likely to cooperate with universities and research institutes than with competitors, customers, or suppliers (Belderbos et al., 2004a). This relationship between size, a proxy of firm resources and capabilities, and somehow more complex innovation activities is also observed while studying in-house R&D performers, contract R&D performers, non-R&D innovators, and technology adopters in European firms (Huang et al., 2010).

In brief, different approaches to innovation bring significant differences in firm performance. While definitions and measurements of innovation strategies have been developed, the issue has remained relatively under-researched in Latin America. Hence, how firms innovate in the region remains an empirical question that this paper is addressing. The identified innovation strategies share some similarities with those found in European firms and, as in the previous literature, are related to different levels of firm performance and are also strongly determined by firm-level conditions.

## 3. Data and Methodology

### 3.1. Data

I use the LAIS dataset (Crespi et al., 2022), a novel dataset that contains harmonized innovation survey data from several Latin American countries. Although there is no formal agreement between Latin American countries regarding minimum content, most of these innovation surveys have a typical structure that includes modules about firms' general characteristics, innovation activities and expenditures, innovation output, human resources, access to finance, impacts of innovations, protection of innovations, cooperation for innovation, sources of information, and obstacles to innovation. While LAIS tackles some of the challenges for comparing the data due to questionnaire differences, not all variables are available for every country in the dataset.[6] Despite this constraint, the dataset still provides several descriptive variables of firms' innovative behavior. Given the objective of this work, I have chosen to work with innovation survey waves and modules that allow comparison in variables that describe how firms innovate in as many countries as possible.[7] Data in LAIS range from surveys conducted between 2007 and 2017, and it is unbalanced in terms of waves per country. Hence, I have decided to work only with surveys conducted between 2012 and 2017 as a compromise between data availability, number of countries included, and comparability in the time dimension.

I restrict the sample to manufacturing firms because only surveys in Chile, Colombia, Ecuador, and Uruguay cover other economic activities. I also limit the sample to firms with ten or more employees since it is the most common (and higher) threshold that defines the targeted

[6] Issues that go from differences on how questions are phrased to the scope of questions referring to the same topic reduce the possibilities of conducting a straight comparison of all variables.
[7] The detailed procedures for the harmonization of these datasets are presented in Crespi et al. (2021).

population in each innovation survey.[8] Innovation strategies are identified by considering only firms that invest in any innovation activity and report having introduced at least a product or process innovation. The reason behind the latter restriction to the sample is that some of the surveys limit the measurement of innovation activities to those aiming only to introduce product and process innovation. In contrast, in others, innovation activities also consider investments in organizational and marketing innovations. Thus, in the latter type of questionnaire, firms can report innovation investments and have introduced only organizational or marketing innovations, while this is not possible for firms responding to the former questionnaire.

Besides the harmonization of the datasets, Crespi et al. (2022) also describe some comparability issues that remain and need to be considered to interpret the results correctly. First, innovation surveys in LAIS have different reference periods. In most countries, this period covers three years, except for Chile and Colombia, where it is two years. I expect that firms that innovate on a non-regular basis are more likely to be identified in surveys with a more extended reference period, affecting the rate of innovative firms between countries and, eventually, the relative incidence of a given innovation strategy. In addition, most countries use their available national business registry or census as the sampling frame for the national innovation survey, with the exception of Panama and Peru. While in the former, the sampling frame is the group of firms that claim to be engaging in scientific and technological activities in their respective national economic census, in the latter, the sampling frame is the sample of firms surveyed in the Annual Economic Survey. In both cases, the fact that the sampling frame is already a selection of firms may be a source of bias towards larger or *better* firms than the typical business in the country.

All surveys also provide sampling weights that enable estimations to be obtained that are representative of the industry at the national level.[9] Using these weights is necessary to adequately depict the behavior of the typical firm in the sector and country. For the sake of comparability and the proper estimation of statistics, the country-wave sampling weights are standardized.

The resulting countries and waves included in the analysis, after the application of variables and survey restrictions, are Argentina 2013 (AR13) and 2017 (AR17), Chile 2015 (CH15) and 2017 (CH17), Colombia 2015 (CO15) and 2017 (CO17), Ecuador 2013 (EC13) and 2015 (EC15), El Salvador 2013 (ES13), Paraguay 2013 (PR13) and 2016 (PR16), Peru 2012 (PE12) and 2015 (PE15), and Uruguay[10] 2013 (UR13). Table 1 presents the key features of the innovation surveys (IS) included in this work.

### 3.2. Methodology

The main objective of the empirical analysis is to identify the predominant innovation strategies performed by Latin American firms. Then, I link these strategies to firm performance, and finally, I identify the main firm characteristics associated with innovation strategy selection. Hence, as in Hollenstein (2003) and Leiponen and Drejer (2007), the first stage consists of identifying the core innovation practices in the region and then the combination of these practices that are applied more commonly by firms, that is, the innovation strategies. In the second stage, I test whether these strategies lead to different performance outcomes. Finally, I relate innovation strategy selection with the main drivers at the firm level.

[8] The criteria are based on annual turnover, the number of employees, or a combination of both. All IS that define the target population based on annual turnover include companies with fewer than ten employees in their sample.
[9] Colombia is the exception since the survey is applied to the entire population of the survey. Therefore, weights are equal to 1.
[10] Although the survey of Uruguay 2016 is available in LAIS, that wave lacks variables which are critical for conducting this analysis.

**Table 1. Description of National Innovation Surveys Included in the Analysis**

| Country | Year of the survey | Period of reference | Sample size* | Expanded* | Innovative* (expanded) |
|---|---|---|---|---|---|
| Argentina | 2013 | 2010–2012 | 3,244 | 17,131 | 9,339 |
| | 2017 | 2014–2016 | 3,577 | 17,148 | 9,885 |
| Chile | 2015 | 2013–2014 | 1,210 | 4,356 | 948 |
| | 2017 | 2015–2016 | 975 | 3,179 | 755 |
| Colombia | 2015 | 2013–2014 | 7,196 | 7,196 | 1,457 |
| | 2017 | 2015–2016 | 7,085 | 7,085 | 1,561 |
| Ecuador | 2013 | 2009–2011 | 1,134 | 2,449 | 1,304 |
| | 2015 | 2012–2014 | 1,553 | 3,596 | 1,910 |
| El Salvador | 2013 | 2010–2012 | 564 | 1,336 | 395 |
| Paraguay | 2013 | 2010–2012 | 339 | 1,157 | 602 |
| | 2016 | 2013–2015 | 388 | 1,104 | 476 |
| Peru | 2012 | 2009–2011 | 908 | 5,177 | 3,447 |
| | 2015 | 2012–2014 | 1,299 | 6,006 | 3,571 |
| Uruguay | 2013 | 2010–2012 | 681 | 2,661 | 716 |

* Only manufacturing firms.

Source: Author's elaboration.

Among the variables available for the sample of country waves, I start working with in-house R&D, which identifies firms actively engaging in knowledge production. External R&D is included separately, providing the space for finding substitutive or complementary patterns relative to in-house R&D. The acquisition of external technologies and knowledge is captured in two separate variables. The first identifies firms that invested in buying embodied technologies, such as machinery, hardware, and software, which are the most frequent innovation investments in the region (IDB, 2014). The second measures involvement in technology transfer activities, such as acquiring licenses, know-how, patents, and other types of external knowledge. The analysis also includes training activities for innovation, particularly relevant for Latin American firms (González-Velosa et al., 2016), and expenditures in engineering and design activities for innovation.[11]

Departing from previous studies that measure engagement in innovation activities through dummies (Frenz and Lambert, 2009; Huang et al., 2010; Jensen et al., 2007; Srholec and Verspagen, 2012), or just by using the total innovation investments relative to turnovers (Leiponen and Drejer, 2007), I use a measure of total investment in each innovation activity standardized by the number of employees in the firm. I assume that this approach represents the importance of each innovation activity to the underlying strategy performed by the firm. However, the inclusion of these variables restricts the sample of Argentina to firms with fewer than 400 employees.[12] The investment intensity in each innovation activity is measured by applying the inverse hyperbolic sine (IHS) transformation to the total investment per employee (Burbidge et al., 1988).[13]

[11] The variable in CH15 and CH17 only includes expenditures in design activities, so it needs to be considered as a lower boundary of the real effort of the firm.
[12] AR13 and AR17 report the number of employees truncated at 400.
[13] Since not all innovation-active firms invest in every innovation activity, firms have some innovation intensities equal to zero. Since the IHS function is defined for zero, it allows the properties of the logarithmic transformation to be obtained without manipulating the original variable.

The second group of variables describes how the innovative company makes use of external resources. The interactive essence of the innovation process highlights the role of suppliers (Pavitt, 1984), clients (von Hippel, 2005), and other market actors in the innovation decisions of the firm (Chesbrough, 2003). Furthermore, complex activities increasingly require opening up the innovation process and exploring knowledge sources around the company (Gassmann, 2006). Hence, details are captured through the inclusion of four organizational sources of information for innovation (clients and suppliers, other firms, research and technology organizations (RTO), and universities) and three public sources (journals, conferences, and the internet). This set of variables proxy the diversity of ideas that fuel the firm's innovation strategy (Leiponen and Helfat, 2010). More active use of external knowledge is explored by adding data about collaboration for innovation with universities, RTOs, and other firms.

Firms' actions to protect their innovations are described by including a set of variables indicating whether the firm has used patents, trademarks, utility models, industrial designs, and copyrights. Crespi et al. (2016) show that less than half of innovative firms in Latin America use intellectual property rights (IPR) to protect innovations. We would expect these tools, particularly patents, to be especially relevant to firms that rely on more sophisticated strategies (Harrison and Sullivan, 2000). However, Hall (2020) and Kim et al. (2012) show that trademarks and utility models, respectively, are used more frequently than patents by domestic firms in middle-income countries. Although potentially informative, I do not include informal methods of protection in the analysis because of data availability. Also, because of data constraints, I cannot describe the firm's innovation output through variables related to the objectives or effects of innovation, like Leiponen and Drejer (2007) and Srholec and Verspagen (2012). Instead, and like Frenz and Lambert (2009), I include a set of dummy variables that identify whether a firm introduces product, process, marketing, or organizational innovations, as defined in the previous version of the Oslo Manual (OECD/Eurostat, 2005). Table 2 summarizes the selected set of variables.

I apply an exploratory factor analysis, using principal-component as the extraction method (PCF), to the selected variables to identify the central innovation practices performed by Latin American firms. That is, innovation practices are the underlying latent factors behind the observable decisions of the firm. Since the variables included in the analysis (Table 2) are continuous above zero and binary, the PCF analysis is conducted by analyzing the polychoric correlation matrix.[14] This matrix is estimated considering the normalized sampling weights to obtain a representative depiction of the behavior of the firms in each country.

I only select factors with eigenvalues greater than 1 (Kaiser criterion), which means that the last retained factor explains a higher share of the variance than the typical single variable. The interpretation of the factors is facilitated by rotating the results, applying a direct oblique transformation (oblimin), which implies that the correlation between factors is allowed. In other words, this method acknowledges that firms may apply a combination of the innovation practices (factors) that I obtain from the PCF analysis.

[14] I use the user-developed Stata command *polychoric.*

**Table 2. Variables Included in the Analysis**

| Variables | Description |
|---|---|
| Innovation activities[15] | |
| Intramural R&D | (IHS) Intramural R&D expenditures (USD$) per employee |
| External R&D | (IHS) Subcontracted R&D expenditures (USD$) per employee |
| ICT and machinery | (IHS) Expenditures in machinery, hardware, or software for innovation (USD$) per employee |
| Technology transfer | (IHS) Expenditures in the acquisition of licenses, patents, know-how, consultancies, and other external knowledge for innovation (USD$) per employee |
| Training | (IHS) Expenditures in training for innovation (USD$) per employee |
| Engineering & design | (IHS) Expenditures in engineering & design for innovation (USD$) per employee |
| Cooperation in innovation activities | |
| Firm cooperation | (0/1) The firm engaged in cooperative innovation activities with competitors or other firms. |
| RTO cooperation[16] | (0/1) The firm engaged in cooperative innovation activities with business associations, consultants, laboratories, or R&D organizations. |
| University cooperation | (0/1) The firm engaged in cooperative innovation activities with universities or other tertiary education organizations. |
| Sources of information for innovation | |
| Clients' and suppliers' sources | (0/1) The firm uses information from clients or suppliers. |
| Firms' sources | (0/1) The firm uses information from competitors or other firms. |
| RTOs' sources | (0/1) The firm uses information from business associations, consultants, laboratories, or R&D organizations. |
| Universities' sources | (0/1) The firm engaged in cooperative innovation activities with universities or other tertiary education organizations. |
| Journals | (0/1) The firm uses information from articles or journals. |
| Conferences | (0/1) The firm use information from conferences or events |
| Internet | (0/1) The firm uses information from the internet. |
| Intellectual property rights | |
| Patents | (0/1) The firm uses patents to protect innovations. |
| Trademarks | (0/1) The firm uses trademarks to protect innovations. |
| Utility models | (0/1) The firm uses utility models to protect innovations. |
| Industrial design | (0/1) The firm uses industrial designs to protect innovations. |
| Copyrights | (0/1) The firm uses copyrights to protect innovations. |
| Innovation output | |
| Product innovation | (0/1) The firm has introduced product innovation. |
| Process innovation | (0/1) The firm has introduced process innovation. |
| Marketing innovation | (0/1) The firm has introduced marketing innovation. |
| Organizational innovation | (0/1) The firm has introduced organizational innovation. |

Source: Author's elaboration.

To identify the innovation strategies, I conduct a cluster analysis using innovation practices obtained from the previous step as the inputs. The objective is to identify distinctive and exclusive groups of firms performing similar combinations of innovation practices, each

[15] Investments are first transformed from local currency to U.S. dollars using annual exchange rates available at the World Development Indicators database (2021).
[16] In the case of AR13, PR16, PE13, and PE16, the variable also includes business associations.

representing an innovation strategy. First, I run a hierarchal cluster analysis, using Euclidean distance and the Wards method for merging clusters. I use the results between 2 and 15 clusters as the starting solutions for a second cluster iteration, this time by the k-means algorithm. The selection of the final number of clusters depends on the share of the explained variance, the benefits of adding one more cluster solution, the distribution of observations between clusters, and the interpretability of the results. Each of these clusters represents an innovation strategy.

The objective of the following step is to test if different innovation strategies also lead to different results. I use two indicators of firm performance: sales growth and labor productivity. I perform an OLS regression restricted to the sample of innovative firms, with innovation strategies as explanatory variables. Finally, I investigate the main firm characteristics that drive innovation strategy selection by estimating a multinomial logit regression. In this model, I include variables related to the availability of resources of the firm, such as the firm size (number of employees), a dummy indicating if the firm has had export activities, a measure of human capital, and an index of the labor productivity of the firm at the beginning of the period of the respective survey.[17] I have also added a set of time, sector, and country dummies.

## 4. Results

### 4.1. Identification of Innovation Strategies

#### 4.1.1 *Innovation Practices*

Table 3 shows the results of the PCF analysis. Seven innovation practices emerge, which I have labeled as exploring, protecting, knowledge partnering, new business practices, intangible investments, incremental product development, and process modernization.

<u>Exploring:</u> This factor mainly encompasses the firm's efforts to search for valuable information, in line with the knowledge-exploration concept developed by Chesbrough (2003). This practice has been classified as a non-pecuniary inbound innovation practice in OI as a means to absorb external ideas and make them fit with the activities of the firm (Dahlander and Gann, 2010). The higher the firm's score on this factor, the higher the breadth of the knowledge search (Leiponen and Helfat, 2010). Despite the conceptual congruence with OI, this innovation practice cannot be directly assimilated into other exercises using a similar methodology. For instance, in Leiponen and Drejer (2007) and Srholec and Verspagen (2012), the use of each type of source of information is tied to specific innovation investments.

<u>Protecting</u>: This practice depicts the approach to intellectual property management in a firm. It includes all IPR types captured in LAIS, in line with statistics showing that firms, especially high-performance ones, use IPR bundles to protect innovations (Dernis et al., 2015; European Patent Office and European Union Intellectual Property Office, 2019). I cannot identify whether IPR bundles are applied to specific products, but only the IPR management decisions of the firm. Hence, this practice depicts the behavior of firms using distinct, unique methods of protection for each product, and those that use, for instance, a patent, a design, and a trademark to protect solely a new good.

[17] Min-max normalization within the sector and country.

**Table 3. Results of Principal-Component Factor Analysis**

| Variables | Innovation practices | | | | | | |
|---|---|---|---|---|---|---|---|
| | Exploring | Protecting | Knowledge partnering | New business practices | Intangible investments | Incremental product development | Process modernization |
| Intramural R&D | 0.07 | 0.02 | -0.07 | 0.01 | **0.62** | 0.02 | -0.25 |
| External R&D | -0.05 | 0.01 | 0.10 | -0.06 | **0.54** | -0.04 | -0.02 |
| ICT & machinery | 0.02 | 0.09 | 0.03 | -0.16 | 0.03 | -0.03 | **0.62** |
| Technology transfer | 0.04 | 0.01 | -0.02 | 0.04 | **0.67** | -0.08 | 0.19 |
| Training | -0.14 | -0.02 | 0.18 | 0.03 | **0.57** | -0.10 | 0.07 |
| Engineering & design | 0.02 | -0.05 | -0.09 | 0.00 | **0.64** | 0.12 | 0.00 |
| Clients & suppliers sources | **0.78** | -0.06 | -0.08 | -0.02 | 0.02 | 0.04 | -0.01 |
| Firms' sources | **0.72** | -0.02 | -0.06 | 0.07 | -0.01 | 0.11 | 0.02 |
| RTOs' sources | 0.26 | 0.03 | **0.68** | 0.08 | 0.03 | -0.08 | 0.07 |
| Universities' sources | **0.39** | -0.02 | **0.69** | 0.04 | 0.00 | -0.26 | -0.02 |
| Journals | **0.83** | 0.04 | 0.08 | 0.00 | 0.00 | -0.02 | 0.04 |
| Conferences | **0.72** | 0.04 | 0.17 | 0.00 | 0.02 | 0.06 | 0.01 |
| Internet | **0.85** | 0.00 | 0.02 | 0.05 | 0.00 | -0.05 | 0.01 |
| Firm cooperation | 0.06 | -0.04 | 0.10 | 0.04 | 0.01 | **0.86** | 0.11 |
| RTO cooperation | -0.06 | 0.06 | **0.69** | 0.11 | 0.04 | **0.41** | 0.02 |
| University cooperation | -0.07 | 0.08 | **0.84** | -0.02 | 0.02 | 0.12 | -0.07 |
| Patents | -0.01 | **0.89** | 0.03 | 0.00 | -0.01 | -0.14 | 0.04 |
| Trademarks | 0.05 | **0.82** | 0.00 | 0.00 | 0.01 | -0.14 | -0.01 |
| Utility models | 0.05 | **0.72** | -0.02 | 0.00 | -0.01 | 0.21 | 0.00 |
| Industrial designs | -0.02 | **0.67** | 0.02 | -0.02 | 0.00 | **0.35** | 0.00 |
| Copyrights | -0.08 | **0.81** | 0.04 | 0.12 | 0.00 | -0.05 | 0.03 |
| Product innovation | 0.25 | 0.34 | 0.00 | -0.08 | 0.11 | **0.40** | **-0.40** |
| Process innovation | 0.10 | 0.07 | -0.07 | 0.05 | 0.03 | 0.19 | **0.75** |
| Organizational innovation | -0.07 | -0.05 | 0.12 | **0.85** | 0.02 | -0.01 | 0.00 |
| Marketing innovation | 0.12 | 0.11 | -0.14 | **0.80** | 0.00 | 0.03 | -0.04 |
| Variance explained | 24% | 11% | 7% | 6% | 5% | 5% | 4% |

Note: N=11,967. Weighted data.
Source: Author's elaboration.

Knowledge partnering: RTOs and universities are essential knowledge providers to the economy. In general, the theoretical discussion describes universities as more important in the scientific or basic-research domain, while RTOs specialize in applied research and technology transfer. Indeed, Giannopoulou et al. (2019) show that European firms that consider knowledge from RTOs as more important for innovation than from universities are less intensive in R&D and less likely to introduce innovations to the world. The opposite is true for firms that consider universities as the most important source of knowledge. This potential complementarity in roles emerges in this practice since firms rely on both types of organizations as sources of valuable information and as partners for innovation.

New business practices: This factor shows that firms frequently engage in marketing and organizational innovations simultaneously. Nevertheless, there is no evident combination of inputs and throughputs that leads to this output. In part, this may be a consequence of questionnaire design, wherein most of the innovation activities are aimed at product or process innovation. Mainly studied as a complement to product and process innovation efforts in manufacturing firms and highlighted as the primary driver of productivity growth in services firms, this practice has also been identified by Frenz and Lambert (2009). Labeled there as "wider innovating," this method emerges not only in pooled data of manufacturing and services firms in high-income countries but also in their sample of Brazilian manufacturing companies.

Intangible investments: This practice aggregates in-house R&D efforts with the acquisition of disembodied technologies and knowledge services to fuel the firm's innovation process. In line with the complementarity often found between Make and Buy, the intensity of acquisition of disembodied technologies cooccurs with investments in internal R&D, training, and engineering and design activities. There is no clear innovation output associated with this factor, implying that the combination of these inputs is used to achieve diverse objectives across the firms. This practice is in line with integrating complementary technologies in the knowledge market, also referred to as the acquisition practice in the OI literature (Dahlander and Gann, 2010). The relevance of R&D in this factor makes it somehow similar to the research-oriented innovation ingredient found in Leiponen and Drejer (2007) and Srholec and Verspagen (2012). However, it strongly differs with respect to the lack of relevance of scientific sources of information. This difference may be a consequence of the lack of complementary knowledge for R&D performers in the local scientific system or attributable to the innovation culture of the typical innovative Latin American firm (Brettel and Cleven, 2011).

Incremental product development: This practice reflects product innovations in partnership or collaboration with other firms in the market and RTOs. Both types of organizations are associated with incremental innovations. First, RTOs tend to act as partners in technology transfer activities, easing the adoption process in firms (Giannopoulou et al., 2019). Second, in general, collaboration with competitors is not a determinant of radical innovation or new product development (Brettel and Cleven, 2011). For instance, in Norway, it has also been related to lower innovative performance (Fitjar and Rodríguez-Pose, 2013). Additionally, industrial design appears relevant to this practice, adding to the interpretation of modifications that are not radical.

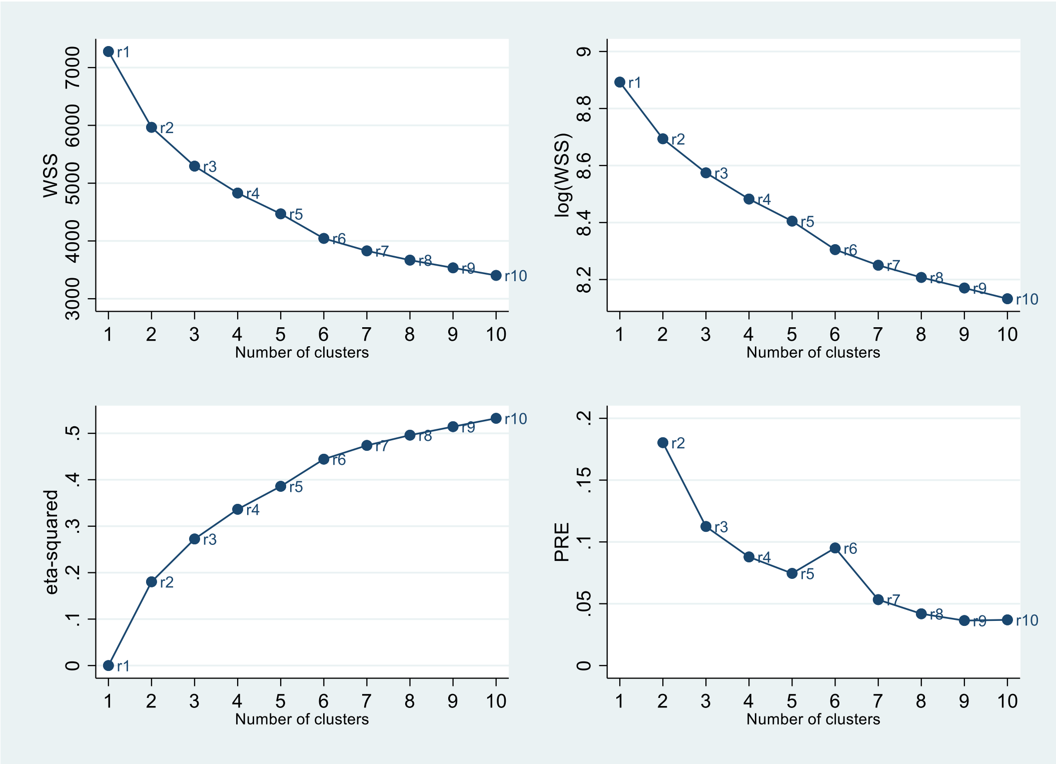
Process modernization: This factor represents one of the most common narratives about innovation in Latin America: investment in embodied technology as a source of innovation. Indeed, this is the factor that explains the lowest proportion of the variance, since it is the most common innovation practice in the sample. Characterized by the acquisition of machinery, hardware, and software, these innovative efforts are remarkably concentrated toward innovation in process. Moreover, it is strongly negatively related to product innovation. This practice has also been found in European firms, known as process modernizing (Frenz and Lambert, 2009), production intensive (Leiponen and Drejer, 2007), and production (Srholec and Verspagen, 2012).

#### 4.1.2 *Innovation Strategies*

So far, I have identified seven innovation practices applied by innovative Latin American firms. Companies apply these practices in different intensities, according to their innovation strategy. Therefore, to discover these strategies, I have identified firms that are instituting similar combinations of innovation practices. The intensity of use of each of these practices reveals the innovation strategy of the firm. To this end, I have performed a cluster analysis (k-means) starting from centroids obtained by previous hierarchical cluster analysis.

Following Makles (2012), this stuy applies several criteria to identify the most suitable cluster solution. The graphical analysis suggests that the data structure does not reveal a clear optimum (Figure 1). There is no evident number of clusters after which the explained variance remains practically unaltered. On the contrary, a continuous parsimonious decrease is observed with an increasing number of clusters. Since the first goal of this exercise is to work with solutions that explain a significant share of the variation in responses, I disregard solutions with two and three clusters since these explain less than 30 percent of the total variance (eta-squared). Solutions with four clusters increase the explained variance up to 34 percent. Then, five and six-cluster solutions increase the explained variance by 5 and 4 percent, respectively. From here, additional clusters increase the explained variance by no more than 3.5 percent. Hence, solutions with four, five, and six clusters could be considered equally valid from a numerical perspective. In this context, I decide to work with four solutions to facilitate the conceptualization of the innovation strategies. Results of cluster analysis with five and six solutions are presented in Appendix A.

**Figure 1. Detecting the Optimal Number of Clusters**




Note: WSS: Within sum of squares. PRE: Proportional reduction of error
Source: Author's elaboration.

Table 4 shows the cluster analysis results, presenting the mean of the factor scores of each of the innovation practices. Scores are normalized with zero mean and standard deviation equals 1. The table describes the four innovation strategies identified in terms of the intensity of each innovation practice. Among these, one innovation strategy, labeled as opportunistic, can be directly recognized from previous studies in Europe. Two strategies labeled production improvement and product-oriented share similarities with strategies identified from previous studies using data from European firms. The remaining strategy, open management, can be classified as a particular case from Latin American firms.

**Table 4. Cluster Analysis: Innovation Strategies**

| Innovation Strategies | Innovation practices | | | | | | |
|---|---|---|---|---|---|---|---|
| | Searching | Protecting | Knowledge partnering | New business practices | Intangible investments | Incremental product development | Process modernization |
| Open management | **0.83** | 0.14 | **1.04** | **0.57** | 0.35 | -0.58 | 0.22 |
| Product-oriented | 0.16 | **0.30** | 0.21 | 0.39 | **1.02** | **1.14** | 0.28 |
| Production improvement | -0.33 | -0.17 | -0.42 | -0.30 | -0.58 | -0.19 | **0.61** |
| Opportunistic | -0.23 | -0.07 | -0.28 | -0.26 | -0.16 | -0.21 | -1.44 |

Note: N=11,967. Weighted data. Cluster k-means starting from solutions of hierarchical cluster analysis using Ward's method with squared Euclidean distance.
Source: Author's elaboration.

- The opportunistic strategy is characterized by below-average scores in all factors. These figures depict an approach to innovation where there is no intensive application of any innovation practice, with a special disregard for process modernization. It is similar to the "low-profile innovators with hardly any external links" in Hollenstein (2003), the "ad-hoc" innovators in Leiponen and Drejer (2007), and the opportunistic and low-profile innovators in Srholec and Verspagen (2012).

- The production improvement strategy describes firms focusing their innovation efforts almost exclusively on process modernization, with below-average engagement in the rest of the practices. The modernization of processes without other significant investments and in a relatively closed manner fits the narrative of incremental improvements to the production process. Although similar to strategies found in the literature, it cannot be directly assimilated to strategies of innovative European firms. Indeed, while the focus on the production process can be found in Leiponen and Drejer (2007) and Srholec and Verspagen (2012), the production improvement innovation strategy lacks external connections and investments in intangibles.

- Firms following a product-oriented innovation strategy are characterized by a relatively high intensity in incremental product development and intangible investments and an active role in protecting while performing above the average in the other innovation practices. This profile shares some traits with strategies identified in European firms, but also some significant differences arise. In brief, product-oriented Latin American firms could be corresponding to a less science-intensive high-profile strategy combined with user-driven in terms of Srholec and Verspagen (2012).

- The remaining innovation strategy, known as open management, is characterized by reliance on introducing new business practices as a distinctive approach to innovation and performing it in a somewhat open way. Indeed, this strategy scores relatively high in Searching and Knowledge partnering. This strategy has not been identified as such in previous similar studies and can be classified as distinctive of the Latin American case. The inbound open approach to management innovation has been discussed in the literature (Ayerbe et al., 2020), but it has been rarely studied empirically. Among these, notably Mol and Birkinshaw (2009) show the importance of external knowledge to the successful introduction of management innovation. The significance of knowledge organizations as partners in management innovation also fits with the evidence where universities are the consultancy providers in the region (Katz and Contreras Romero 2009) and the knowledge providers for organizational and managerial innovation in low- and medium-technology industries (Abbate et al., 2020).

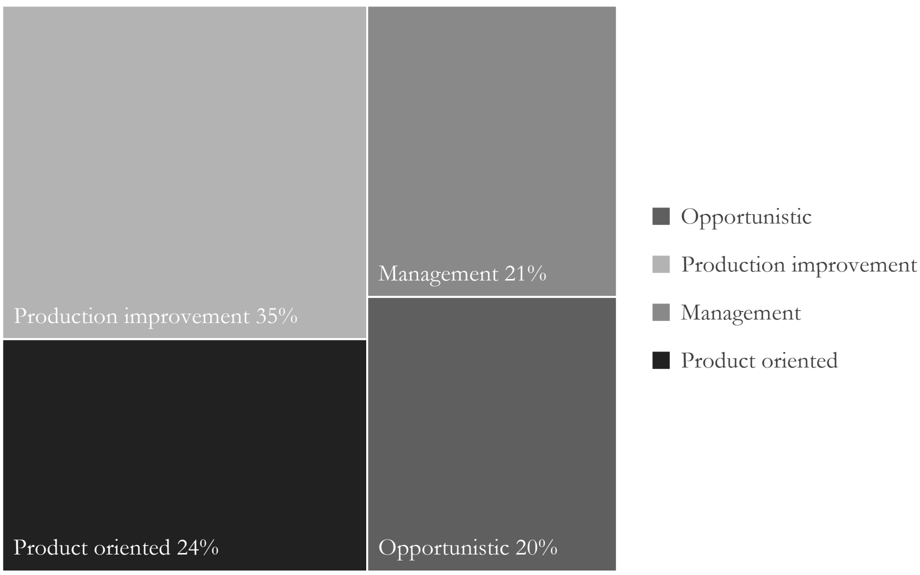
### 4.2. Distribution of Innovation Strategies

Figure 2 shows the preferred innovation strategy among Latin American innovative firms. Thirty-five percent of these firms follow a production improvement strategy. One out of four prefers a product-oriented approach, while nearly the same share (20 percent) of firms are classified as opportunistic and open management innovators.

Figure 3 shows a significant overlap in total innovation expenditures per worker between different strategies followed by the firm. On average, firms following the product-oriented strategy tend to invest more intensively than the other innovative firms. Nevertheless, the differences are less noticeable when comparing production improvement, open management, and even opportunistic. Hence, while the density of investment is nearly the same, the difference is in how these firms are innovating.

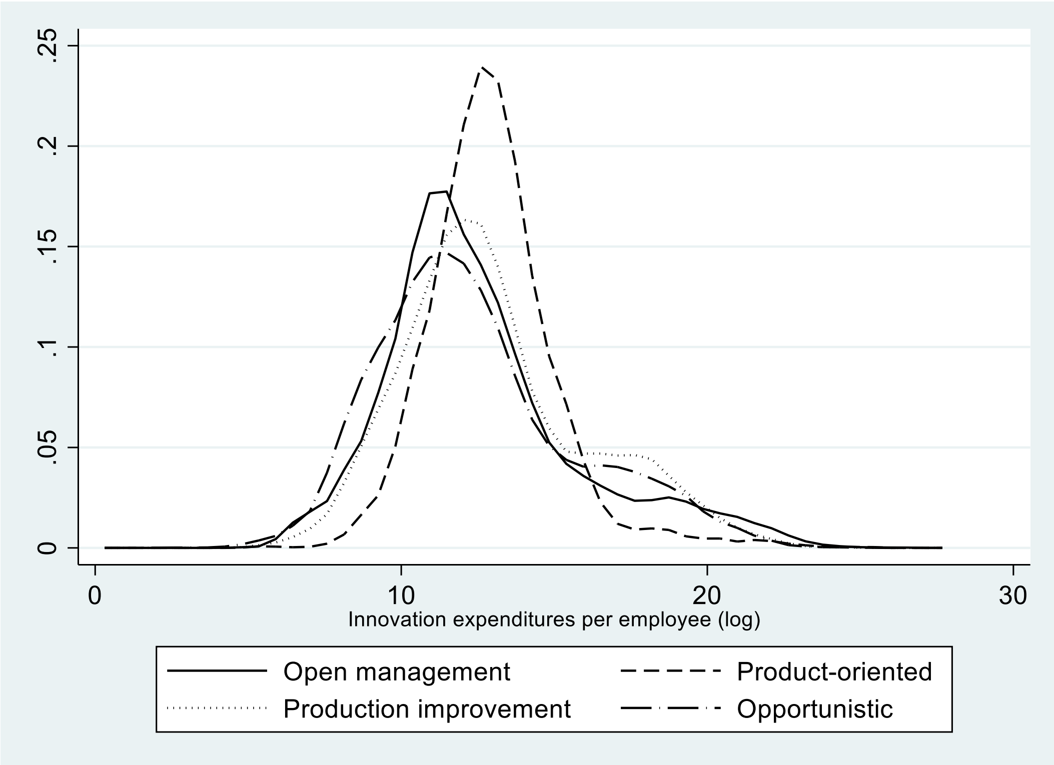
Another way to look at how the identified innovation strategies behave compared to existing classifications is to use the taxonomy of manufacturing activities according to its R&D intensity developed by the OECD (Galindo-Rueda and Verger, 2016). Figure 4 shows some regularities that emerge. There is a relationship between preferred innovation strategies and R&D investments at the sectoral level. The higher the R&D intensity, the higher the share of product-oriented innovators. Product-oriented innovators represent a fifth of the innovators in medium-low R&D intensity sectors and reach nearly half of innovative firms in high R&D intensity sectors. The opposite trend can be observed when focusing on production improvement. This strategy becomes less frequent when the R&D intensity of the sectors is higher. Thus, while medium-low and medium R&D intensity sectors represent 40 and 32 percent of innovative firms, respectively, those figures fall to 23 and 20 percent. The share of open management innovators remains relatively consistent across sectors. Roughly one out of five innovative firms follows this strategy but in high R&D intensity sectors, representing 17 percent of innovators. Finally, the share of opportunistic innovators is similar between activities classified as medium-low, medium, and high R&D intensity. Somehow unexpectedly, opportunistic innovation is the second most frequently used strategy in medium-high R&D intensity sectors.

**Figure 2. Incidence of Innovation Strategies among Innovative Firms**



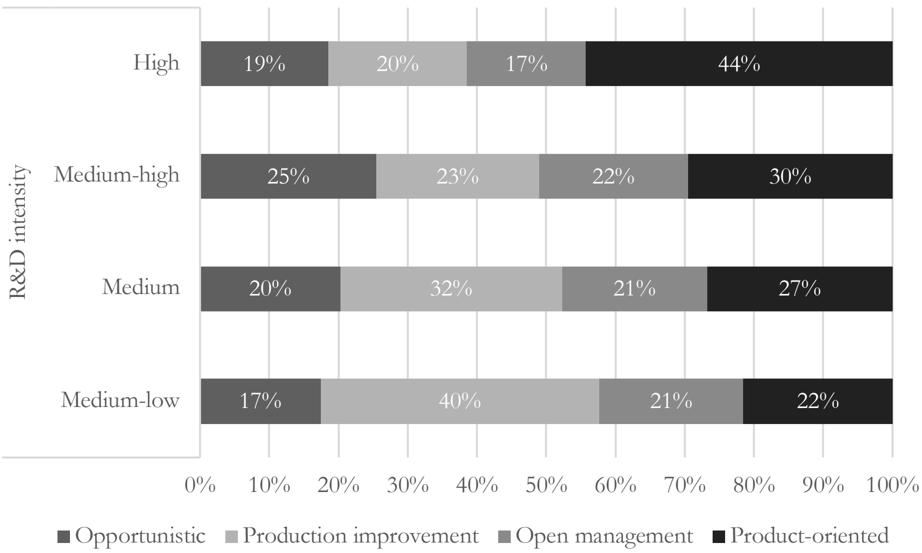

Source: Author’s elaboration.

**Figure 3. Density of Innovation Expenditures by Strategy**



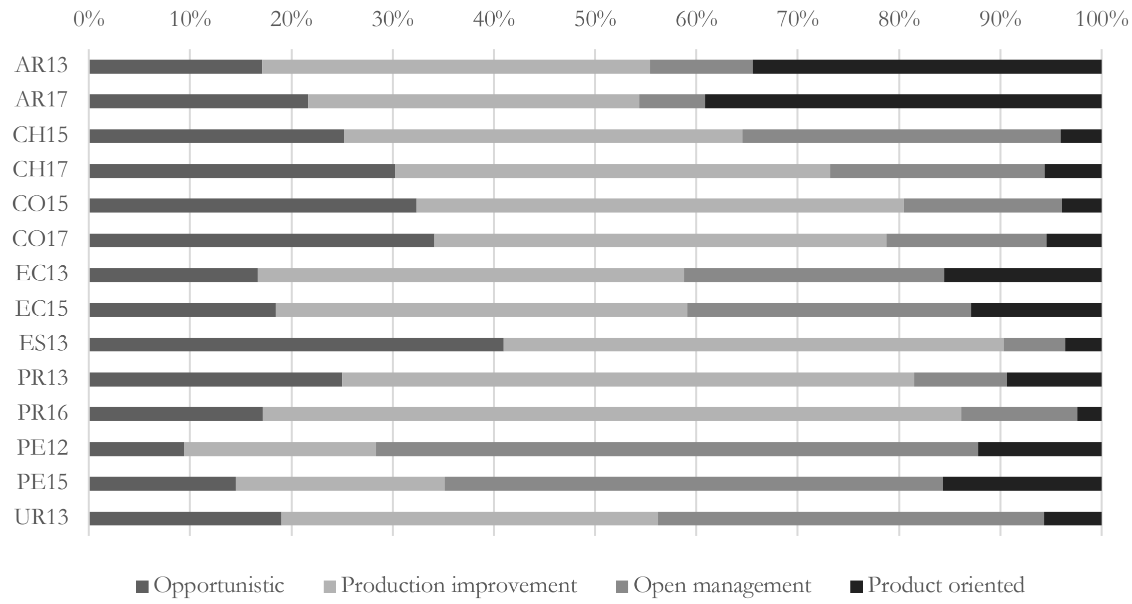

Source: Author's elaboration.

**Figure 4. Incidence of Innovation Strategies across Groups of Sectors**




Note: Because of restrictions on the availability of sectoral data in CH, 43 percent of valid observations from CH15 and 26 percent from CH17 are excluded from this graph. Sectors classified according to their R&D intensity (Galindo-Rueda and Verger, 2016).
Source: Author's elaboration.

**Figure 5. Incidence of Innovation Strategies across Countries**




Source: Author's elaboration.

Figure 5 shows the distribution of innovation strategies between countries. In countries with two consecutive innovation surveys, some differences can be observed, but most of them show a consistent distribution of innovation strategies across time. Some regularities emerge. The first one is clear. The production-improvement is the most popular strategy not only in the sample but also in almost all countries, where it ranges between 38 to 69 percent of innovative companies. At the same time, product-oriented is the least-followed strategy in almost every country, apart from Argentina. Indeed, Argentina appears to be the only country where the share of product-oriented innovative firms is relatively significant. That same pattern, but for open management innovative firms, appears in Peru. These two particularities certainly can reflect idiosyncratic approaches to innovation, but there are also differences in the sample of firms in both countries. In Argentina, firms with 400 employees or more are not in the sample, and in Peru, there is a noticeable difference in the sampling frame compared to the other countries in LAIS (Crespi et al., 2022). Hence, these two country-level statistics need to be interpreted with particular caution.

## 4.3. Innovation Strategies and Firm Performance

Table 5 shows the simple relationship between innovation strategies and firm performance. Both indicators—sales growth and sales per employee—are standardized by the average growth and productivity level in the same industry, country, and period to remove common trends. Sales per employee refer to the last year available in each survey. Following Mohnen et al. (2006), from now on, I remove from the analysis firms with an annual sales growth rate higher than 87 percent and lower than -22.5 percent.[18]

Unsurprisingly, non-innovators are the group with the lowest level of sales per employee. Firms following opportunistic and production improvement strategies have, on average, 2 percent higher sales per employee. The gap rises to 3 percent compared to open management innovators and nearly 5 percent with product-oriented firms. The differences in medians almost replicate the differences between means, suggesting a symmetrical distribution of this variable.

[18] The authors remove firms with growth rate higher than 250 percent and lower than -40 percent between 1990 and 1992.

Non-innovators are also the worst-performing group in terms of sales growth, with an average of 0.6 points below the industry's average growth. Opportunistic innovators present the lowest average growth rate among innovators, 0.2 points below the sectoral average. Open management, product-oriented, and production-improvement innovators present remarkably similar average sales growth, almost one point above the average of the industry. Median values are smaller for all groups, suggesting a variable skewed to the right.

**Table 5. Firm Performance by Innovation Strategy**

| Innovation Strategies | Normalized sales growth | | Sales per employee (log) | |
|---|---|---|---|---|
| | Mean | Median | Mean | Median |
| Non-innovators | -0.6% | -3.2% | 10.7 | 10.7 |
| Open management | 0.8% | -1.8% | 11.0 | 11.0 |
| Product-oriented | 0.8% | -1.9% | 11.2 | 11.2 |
| Production improvement | 0.9% | -1.6% | 10.9 | 10.9 |
| Opportunistic | -0.2% | -2.9% | 10.9 | 10.8 |

Source: Author's elaboration.

To study how innovation strategies affect firm performance, I estimate a linear regression of sales growth and (revenue) labor productivity as a function of innovation strategies, controlling for observables characteristics. I disregard non-innovative firms from the regression since my main interest is to identify differences in firm performance between innovative firms. However, it needs to be borne in mind that the results are affected since I am not addressing selectivity in innovation involvement.

I include the maximum number of control variables available for all surveys included in this analysis. These are the size of the firm (log of the number of employees), sales per employee at the first year of the period covered by each survey, the percentage of the labor force with at least a college degree, and a dummy variable indicating whether the firm has exported during the period of the survey. Aggregated sectoral dummies, defined by the level of R&D intensity, and country dummies are also included. Finally, I include a set of time dummies indicating if the observation comes from a survey conducted in 2012–2013, 2014–2015, or 2016–2017.

Table 6 shows the results of OLS regressions of sales growth and labor productivity. Regression (1) confirms that, on average, open management, product-oriented, and production improvement firms have higher growth rates than opportunistic innovators, but some differences in level between strategies arise. By adding more controls in regression (2), these differences in performance become even more significant. Keeping opportunistic innovators as the base category, production improvement firms have a 1.1 percent higher growth rate. The coefficient goes up to 1.8 percent in the case of open management innovators and up to 2.3 percent for product-oriented firms. The difference between the coefficients of open management and product-oriented is not statistically significant, as well as with production improvement. However, the difference between the growth rate of product-oriented and production improvement is statistically significant.

Regression (3) shows that product-oriented and open management firms have higher levels of sales per employee than opportunistic and production improvement. By adding more controls in regression (4), only the difference in favor of open management innovative firms remains significant, associated with sales per employee 3.4 percent higher than opportunistic firms, while the coefficient of the latter and strategies product-oriented and production improvement are practically the same. Although I cannot measure the level of management capacities, the importance of introducing management innovation to productivity seems to be in line with findings that correlate management capacities and firm performance (Bloom et al., 2019; Mol and Birkinshaw, 2009).

**Table 6. Firm Performance and Innovation Strategies**

| | Normalized sales growth | | Sales per employee (log) | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | Coef. | Coef. | Coef. | Coef. |
| Open management | 0.010* | 0.018*** | 0.285*** | 0.034** |
| | 0.006 | 0.006 | 0.033 | 0.016 |
| Product-oriented | 0.016*** | 0.023*** | 0.230*** | -0.007 |
| | 0.006 | 0.006 | 0.030 | 0.014 |
| Production improvement | 0.009* | 0.011** | 0.029 | 0.006 |
| | 0.005 | 0.005 | 0.028 | 0.013 |
| Opportunistic | | | | |
| Size (log) | | -0.006*** | | 0.080*** |
| | | 0.002 | | 0.006 |
| Initial labor productivity (log) | | -0.027*** | | 0.850*** |
| | | 0.002 | | 0.008 |
| Employees with a college degree (%) | | 0.053*** | | 0.618*** |
| | | 0.015 | | 0.062 |
| Export (dummy) | | 0.004 | | 0.021* |
| | | 0.004 | | 0.011 |
| Constant | 0.009 | 0.026*** | 11.159*** | 10.809*** |
| | 0.006 | 0.008 | 0.030 | 0.023 |
| Sector dummies | Yes | Yes | Yes | Yes |
| Country dummies | Yes | Yes | Yes | Yes |
| Time dummies | Yes | Yes | Yes | Yes |
| Number of obs. | 8,778 | 8,778 | 8,778 | 8,778 |
| Ad. R sq. | 0.01 | 0.03 | 0.13 | 0.81 |
| F | 7.3 | 15.7 | 80.2 | 1380.4 |

* p<0.1, ** p<0.05, *** p<0.01. Robust standard errors.
Note: Observations from CO15 are not included because that wave lacks data of sales at the beginning of the period.
Source: Author's elaboration.

I have performed additional regressions adding variables that are not available for all countries to test if these new specifications affect the coefficients associated with innovation strategies. Thus, I include a variable indicating if the firm has foreign capital, which drops Colombia, and a dummy measuring if the firm belongs to a corporate group, and the firm's age, which drops Argentina. Despite some changes in the value of the coefficient, the results basically remain unaltered.[19] Innovation strategies are linked to different firm results. Among these strategies, the product-oriented innovation strategy is related to the highest sales growth rate and the open management innovation strategy to higher labor productivity levels.

[19] These additional estimations are presented in Appendix B.

### 4.4. Drivers of Innovation Strategy Selection

In this section, I explore the main observable characteristics of the firm that relate to the selection of the identified innovation strategies. To this end, I run a multinomial logit regression on the entire sample of firms, with non-innovators as the base category.

The size of the firm may be a suitable proxy for businesses' resources and capabilities. Indeed, most of the empirical evidence of innovation in Latin America considers company size to be one of the main determinants of innovation and R&D decisions (Crespi et al., 2016; Crespi and Zuñiga, 2012). Hence, the size of the company should play a significant role in determining the approach to innovation. The firm's export orientation may also affect the innovation strategy decision because firms competing in international markets may have different capacities than purely domestic firms.

I expect that the share of the labor force with tertiary education would affect not only a firm's decision to innovate, as in (Crespi et al., 2016), but also the way of doing it. Firms with a relatively high proportion of professionals may have relatively more human capital and be more intensive in business tasks that require those skills, therefore affecting the type of innovation needed by the firm. Finally, I add an index of the firm's productivity level by normalizing (min-max) sales per employee in the sector and country of the firm at the first year of the period covered in the corresponding survey. The assumption is that this index would proxy the productive capabilities of the firm, suggesting that more complex innovation strategies are feasible and profitable.

Table 7 shows the results of the regression. The propensity to innovate, as is well known, increases with firm size. However, the effect is not the same for all strategies. The opportunistic strategy does not appear to be related to firm size. On the contrary, larger firms are associated with an increased likelihood of pursuing either open management or production improvement innovation and, to an even greater extent, a product-oriented innovation strategy. However, the relationship between the log of firm size and the probability of following a product-oriented innovation strategy appears to follow an inverted-U pattern.

Exporting firms are more likely to engage in product-oriented innovation than in other innovation strategies. Indeed, while exporting firms are nearly 3 percent more likely to pursue open management or opportunistic innovation, the marginal effect reaches 4 percent for product-oriented innovation. Somewhat surprisingly, the export orientation of the firm is not related to the production improvement strategy.

Firms with more human capital are more likely to engage in open management innovation, which is in line with previous findings in other regions (Mol and Birkinshaw, 2009). Almost as important is the link of this variable to the adoption of a product-oriented strategy. Smaller, but also significant, is the relationship with the opportunistic approach to innovation. Similar to what is observed with exporting, there is no significant relationship between human capital and the probability of pursuing a production improvement strategy.

Finally, firms closer to the domestic productivity frontier are more prone to innovate following a production improvement innovation strategy. Indeed, these firms are almost twice as likely to follow this strategy than to follow a product-oriented or open management innovation strategy. On the contrary, these firms are less likely to be non-innovators and are less likely to innovate in an opportunistic way.

**Table 7. Marginal Effects of Multinomial Logit of Determinants of Innovation Strategies Selection**

| | Innovation strategies | | | | |
|---|---|---|---|---|---|
| | Non-innovators | Opportunistic | Open management | Production improvement | Product-oriented |
| Size (log) | -0.118*** | 0.006 | 0.028*** | 0.028** | 0.056*** |
| | 0.017 | 0.011 | 0.010 | 0.013 | 0.011 |
| Size sq. (log) | 0.005** | 0.000 | 0.000 | -0.001 | -0.004*** |
| | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 |
| Employees with college degree (%) | -0.263*** | 0.061*** | 0.124*** | -0.037 | 0.114*** |
| | 0.034 | 0.017 | 0.015 | 0.026 | 0.016 |
| Export (dummy) | -0.088*** | 0.029*** | 0.028*** | -0.010 | 0.041*** |
| | 0.008 | 0.005 | 0.005 | 0.007 | 0.005 |
| Proximity to productivity frontier | -0.066*** | -0.019* | 0.018* | 0.041*** | 0.026** |
| | 0.017 | 0.011 | 0.011 | 0.014 | 0.011 |
| Tech. sector dummies | | | Yes | | |
| Country dummies | | | Yes | | |
| Time dummy | | | Yes | | |
| Number of obs. | | | 14,334 | | |

* p<0.1, ** p<0.05, *** p<0.01. Robust standard errors.
Source: Author's elaboration.

In brief, product-oriented firms tend to have higher capacities than other firms, whether in terms of resources (size), human capital, commercial capabilities related to exporting, and to a certain extent, productivity levels. In contrast, and somewhat expectedly, the opportunistic strategy does not reveal a distinct set of firm characteristics that determine its adoption. Firms following a production-improvement approach tend to be those that are already performing high in productivity. Finally, open management innovation is preferred by firms with higher relative levels of human capital.

## 5. Conclusions

Understanding how firms innovate is crucial for effective innovation policy design. For this study, I used the LAIS dataset, a unique database of harmonized innovation survey data from ten Latin American countries, to produce a detailed analysis of how firms innovate in the region. Combining PCF and cluster analysis, I have extracted from the data the critical innovation practices applied by Latin American firms and, by clustering firms with a similar combination of innovation practices, a set of the main innovation strategies.

The dataset allowed me to identify seven innovation practices and four innovation strategies. These are: product-oriented, production improvement, opportunistic, and open management. The first three innovation strategies can be linked, directly or partially, to strategies found in similar empirical analyses in European firms. The exception is the open management innovation strategy which, although discussed in the management literature, appears to be idiosyncratic to Latin American firms.

The fact that the open management innovation strategy emerges in this set of Latin American firms is even more critical, considering that it is related to superior performance in labor productivity. More evident are the differential effects when looking at sales growth. Firms following a product-oriented approach enjoy the highest sales growth rate among innovative firms, followed by open management and production improvement innovative firms—all above the sales growth rate of opportunistic innovators.

The selection of these strategies is strongly related to the observables of the firm. Firms pursuing a product-oriented innovation strategy tend to have higher productive and commercial capacities than the rest. Firms with higher productivity levels prefer to rely on a production-improvement approach, somehow reinforcing that advantage in the domestic market. Firms with higher human capital levels are more prone to follow an open management innovation strategy, while opportunistic innovators do not appear to have any evident identifiable characteristic.

These differences need to be considered when designing innovation policy. So far, the typical policy instrument in the region focuses on the technological merits of innovation projects, and even in specific activities such as R&D. These results emphasize the relevance of a broader approach to understanding and supporting innovation in firms. A non-trivial share of firms would benefit from explicitly considering support for activities aiming to pursue innovation in management, especially those co-developed with external knowledge providers.

Although novel for the region and unprecedented in country coverage, these results still need more further elaboration to assess their generalizability to other Latin American countries not included in LAIS, and to determine whether it remains relevant when adding new innovation survey waves. Both activities would be potentially feasible soon if LAIS continues to be updated and other countries assess the benefits of sharing data with the research community. Also, having more countries and data points would facilitate the implementation of more sophisticated methods that would overcome some restrictions derived from the cross-sectional characteristics of most country surveys, for example, by testing multilevel multinomial models of innovation strategy selection that allow for random effects at the firm level. The extent to which innovative firms tend to stick permanently to one of these innovation strategies and how much of that behavior is modifiable by policy are certainly other suggested research questions that derive from this work.

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## Appendix A

**Table A1. Cluster Analysis: Five-cluster Solution**

| Innovation Strategies | Innovation practices | | | | | | |
|---|---|---|---|---|---|---|---|
| | Searching | Protecting | Knowledge partnering | New business practices | Intangible investments | Incremental product development | Process modernization |
| Cluster 1 | **0.84** | 0.08 | **0.91** | **0.63** | 0.07 | -0.56 | 0.17 |
| Cluster 2 | 0.25 | **0.32** | 0.54 | 0.34 | **1.99** | 0.39 | 0.33 |
| Cluster 3 | -0.41 | -0.19 | -0.44 | -0.34 | -0.57 | -0.42 | **0.61** |
| Cluster 4 | 0.11 | 0.13 | -0.03 | 0.17 | -0.16 | **1.42** | 0.30 |
| Cluster 5 | -0.25 | -0.05 | -0.30 | -0.28 | -0.14 | -0.24 | -1.49 |

Note: N=11,967. Weighted data. Cluster k-means starting from solutions of hierarchical cluster analysis using Ward's method with squared Euclidean distance.
Source: Author's elaboration.

**Table A2. Cluster Analysis: Six-cluster Solution**

| Innovation Strategies | Innovation practices | | | | | | |
|---|---|---|---|---|---|---|---|
| | Searching | Protecting | Knowledge partnering | New business practices | Intangible investments | Incremental product development | Process modernization |
| Cluster 1 | **0.87** | -0.13 | **0.96** | 0.58 | 0.05 | -0.56 | 0.14 |
| Cluster 2 | 0.27 | **2.59** | 0.32 | **0.69** | 0.36 | 0.11 | 0.14 |
| Cluster 3 | 0.23 | 0.04 | 0.46 | 0.29 | **1.95** | 0.39 | 0.31 |
| Cluster 4 | -0.41 | -0.21 | -0.45 | -0.35 | -0.58 | -0.42 | **0.61** |
| Cluster 5 | 0.11 | -0.07 | -0.05 | 0.13 | -0.19 | **1.43** | 0.31 |
| Cluster 6 | -0.28 | -0.10 | -0.31 | -0.29 | -0.16 | -0.24 | -1.50 |

Note: N=11,967. Weighted data. Cluster k-means starting from solutions of hierarchical cluster analysis using Ward's method with squared Euclidean distance.
Source: Author's elaboration.

## Appendix B

**Table B1. Normalized Sales Growth and Innovation Strategies**

| | Normalized sales growth | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | Coef. | Coef. | Coef. | Coef. |
| Open management | 0.024*** | 0.024*** | 0.021*** | 0.020** |
| | 0.006 | 0.006 | 0.008 | 0.008 |
| Product-oriented | 0.026*** | 0.026*** | 0.028*** | 0.028*** |
| | 0.006 | 0.006 | 0.010 | 0.010 |
| Production improvement | 0.016*** | 0.016*** | 0.014* | 0.015* |
| | 0.005 | 0.005 | 0.008 | 0.008 |
| Opportunistic | | | | |
| Size (log) | -0.005*** | -0.005*** | -0.006** | -0.004* |
| | 0.002 | 0.002 | 0.002 | 0.002 |
| Initial labor productivity (log) | -0.028*** | -0.029*** | -0.026*** | -0.025*** |
| | 0.002 | 0.002 | 0.003 | 0.003 |
| Share undergraduates (percentage) | 0.054*** | 0.053*** | 0.067*** | 0.062*** |
| | 0.016 | 0.017 | 0.021 | 0.021 |
| Export (dummy) | 0.002 | 0.002 | 0.012* | 0.014** |
| | 0.004 | 0.004 | 0.007 | 0.007 |
| Foreign capital (dummy) | | 0.006 | 0.006 | -0.001 |
| | | 0.006 | 0.008 | 0.008 |
| Group (dummy) | | | | 0.014** |
| | | | | 0.007 |
| Age (log) | | | | -0.096*** |
| | | | | 0.034 |
| Age squared (log) | | | | 0.013** |
| | | | | 0.005 |
| Constant | 0.018** | 0.019** | 0.048*** | 0.203*** |
| | 0.009 | 0.009 | 0.018 | 0.055 |
| Excluded countries | CO | CO | AR/CO | AR/CO |
| Sector dummies | Yes | Yes | Yes | Yes |
| Country dummies | Yes | Yes | Yes | Yes |
| Time dummies | Yes | Yes | Yes | Yes |
| Number of obs. | 7,564 | 7,564 | 3,845 | 3,845 |
| Ad. R sq. | 0.04 | 0.04 | 0.04 | 0.05 |
| F | 15.5 | 14.7 | 9.6 | 9.0 |

* p<0.1, ** p<0.05, *** p<0.01
Source: Author's elaboration.

**Table B2. Sales per Employee (Log) and Innovation Strategies**

| | Sales per employee (log) | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | Coef. | Coef. | Coef. | Coef. |
| Open management | 0.047** | 0.048*** | 0.051* | 0.045* |
| | 0.019 | 0.019 | 0.027 | 0.027 |
| Product-oriented | 0.001 | 0.001 | -0.007 | -0.015 |
| | 0.016 | 0.015 | 0.034 | 0.033 |
| Production improvement | 0.017 | 0.016 | 0.026 | 0.029 |
| | 0.015 | 0.015 | 0.026 | 0.026 |
| Opportunistic | | | | |
| Size (log) | 0.083*** | 0.078*** | 0.081*** | 0.071*** |
| | 0.006 | 0.006 | 0.009 | 0.010 |
| Initial labor productivity (log) | 0.840*** | 0.836*** | 0.816*** | 0.811*** |
| | 0.009 | 0.009 | 0.014 | 0.014 |
| Share undergraduates (percentage) | 0.593*** | 0.570*** | 0.904*** | 0.866*** |
| | 0.069 | 0.070 | 0.100 | 0.101 |
| Export (dummy) | 0.044*** | 0.039*** | 0.088*** | 0.087*** |
| | 0.012 | 0.012 | 0.021 | 0.021 |
| Foreign capital (dummy) | | 0.087*** | 0.092*** | 0.054* |
| | | 0.020 | 0.029 | 0.030 |
| Group (dummy) | | | | 0.135*** |
| | | | | 0.024 |
| Age (log) | | | | -0.131 |
| | | | | 0.105 |
| Age squared (log) | | | | 0.021 |
| | | | | 0.017 |
| Constant | 10.774*** | 10.791*** | 10.574*** | 10.777*** |
| | 0.026 | 0.027 | 0.052 | 0.168 |
| Excluded countries | CO | CO | AR/CO | AR/CO |
| Sector dummies | Yes | Yes | Yes | Yes |
| Country dummies | Yes | Yes | Yes | Yes |
| Time dummies | Yes | Yes | Yes | Yes |
| Number of obs. | 7,564 | 7,564 | 3,845 | 3,845 |
| Ad. R sq. | 0.79 | 0.79 | 0.77 | 0.78 |
| F | 1034.1 | 987.6 | 612.6 | 539.1 |

* p<0.1, ** p<0.05, *** p<0.01
Source: Author’s elaboration.