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Obstacles and Drivers of Innovation Performance: Empirical Evidence from Colombian Firms in the Service Sector

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Abstract

This article investigates the role of internal and external factors that drive or hinder the innovation performance of firms in the Colombian services sector. Based on firm-level data for 2018-2019 from the Survey of Development and Technological Innovation (EDIT), we estimated a Heckman selection model in two stages to moderate the potential selection bias caused by the firms' decisions to innovate. Then, a probabilistic ordered model with a selection equation was used to define innovative decisions and evaluate innovative performance. Two sets of variables measuring innovation capabilities, external linkages, and obstacles to innovative performance were considered. The results show that a lack of qualified personnel, uncertain demand for innovative goods and services, and lack of an intellectual property system to protect innovation hinder innovation performance. At the same time, other factors exhibit results that contradict the dynamic capabilities framework. The evidence suggests a negative correlation between unobserved factors that improve innovative performance and those that induce firms to innovate. This approach shows that although factors associated with public sector linkages play a role in inducing firms to innovate, they were overestimated in previous papers; therefore, those linkages were taken as significant to explain innovative performance.

Keywords: innovation; innovative performance; obstacles; emerging economies.

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1 Introduction

Innovation is one of the main strategies for the growth and economic development of firms (Costa, 2024; Gallego et al., 2015; Robertson et al., 2023; Shaik et al., 2023). On the one hand, the literature considers innovation in analogy with the evolutionary life cycle of products and production processes (Dinali et al., 2020). Thus, innovation defines the survival characteristics of organizations in a competitive context, the so-called Schumpeterian process of creative destruction (Teece et al., 1997). From this perspective, innovation acquires a dual nature: process-outcome (OECD/Eurostat, 2018).

However, from the perspective of empirical studies, to collect, report, and use innovation data, the OECD proposes breaking down this duality through the concepts of "innovation activities"

(process) and innovation (outcome). This duality delimits the identification strategies implemented by empirical studies on innovation based on the analysis of the Investment-Development-Innovation cycle.

In their now classic article, Crepon et al. (1998) described innovation as a business strategy and process in three stages: first, investment in Research and Development (R&D), which generates new knowledge; second, knowledge, which is received and incorporated by firms, and is then translated into innovations; third, innovations, the product of knowledge, are finally brought to the market to generate economic value. These stages gave rise to the so-called CDM (the acronym of the three authors' names, Crépon, Duguet, and Mairesse) model to estimate the knowledge production function. This approach proposes a way to minimize the problems of selectivity and endogeneity by estimating the relationship between R&D, innovation, and productivity (Dinali et al., 2020), which is why it is the main methodological orientation in the literature.

On the other hand, since the work developed by Jensen et al. (2007), the literature on business innovation proposed two innovation modes: DUI (Doing, Using, and Interacting) learning-by-doing, by-using, and by-interacting and STI (Science, Technology, and Innovation) technology-based innovation (Calvo et al., 2022; Parrilli & Radicic, 2021; Santos et al., 2022). Additionally, extensive empirical literature has researched the driving forces of successful innovation in both the manufacturing and service industries (Autant Bernard et al., 2010; Chichkanov et al., 2021; Fuentes et al., 2020; Galende & de la Fuente, 2003; Martinez et al., 2011; Singh et al., 2019), but few studies have focused on the obstacles that firms have in emerging economies (Mateut, 2018; Ortiz & Fernandez, 2022). Thus, we have contributed to filling the gap in the literature concerning barriers to innovation of service sector firms in emerging economies.

Some limitations to innovation differ in the case of emerging markets compared to developed markets (Geldes et al., 2017). Although the innovation system across countries can promote prosperity in their firms, the success or failure of innovation depends on a set of factors and heterogeneous contexts, where human capital and research, infrastructure, and business sophistication could be innovation drivers (Costa, 2014), but also a less mature capital market could affect the innovative investment of firms as a result of the financial constraints that exist in developed economies (Mateut, 2018). Buitrago and Barbosa (2020) pointed out that companies spending on R&D, the availability of research and training services, and university-industry collaboration in R&D encourage innovation and competitiveness by helping businesses adapt rapidly to a changing environment. Even so, from an institutional perspective, a weak institutional environment creates structures that damage the completion of contracts, increasing transaction costs and hindering innovation (North, 1990). For instance, the R&D capacities tend to be highly concentrated within universities or high-tech enterprises with a low transfer of technologies from these institutions to the private sector (Dinali et al., 2020). Moreover, firms' poor strategies and difficulties are reinforced by a weak innovation system in emerging economies (Cuervo-Cazurra et al., 2019).

Concerning the service sector, companies must innovate to provide their customers with better service and stand out in the market (Chen & Chang, 2011; Gallego et al., 2015). In this sense, service innovation is intrinsically different from a "product" as it generally lacks the tangible nature of product innovation. Services can be highly customized according to the needs of the client/customer and include many different stakeholders (Durst et al., 2014). Furthermore, firms in the service sector of emerging economies are restricted by factors such as a lack of knowledge or technology and limited R&D investment and capability, making it challenging to innovate (Ortiz & Fernandez, 2022).

Few empirical studies have explained the factors that influence technological innovation in the Colombian context (Henao, 2018). This could be due to the lack of instruments for collecting

information on innovation in the country, considering that the current source of information, the Survey of Development and Technological Innovation (EDIT – in Spanish), was implemented for the first time in 2004-2005.

The first group of studies used the different rounds of this survey as a source and focused on analyzing innovation inputs through econometric methods. For instance, Langeback and Vasquez (2007), in their study about the determinants of innovative efforts in the Colombian manufacturing industry, concluded that the participation of foreign capital, labor force training, and firm size are the determinants of innovative activity. For his part, Velez-Ospina (2009) found that in Bogota's service sector firms, R&D investment increases with firm size and, in all cases, corresponds positively to the level of qualification. Ramirez et al. (2019) extend the CDM model to explore the relationship between R&D, innovation, and productivity in the Colombian manufacturing industry. Their findings show that human capital is relevant to the R&D, innovation, and productivity of these firms. Lastly, Barrios-Aguirre et al. (2024) focus on the impact of open innovation and confidentiality agreements on innovative performance.

The second group of studies is also based on the EDIT. However, these studies were carried out to understand the relationship between the input and output of innovation in an analytical way. Orozco et al. (2010) conducted a multilevel analysis to compare the innovative performance of companies (with and without research and development departments) in Colombia. These authors identified that the variables that affect a firm's innovation are organizational networks, organizational culture, training involving a significant degree of complexity, and the number of professionals with doctorates. Meanwhile, Malaver and Vargas (2011) analyzed the inputs and outputs of innovation based on the same survey, but only for Bogota and Cundinamarca. They established a method to classify the type of innovation according to two criteria: the degree of novelty (new with patent, new without patent, significantly improved, or without developments) and the scope of conformation to the market (none, company, international or national).

In this context, the main goal of this paper is to identify the role of internal and external factors that drive or hinder the firm's innovative performance in the Colombian services sector. We used a cross-sectional data sample of 9,304 companies in the service sector for the period 2018-2019 from the Survey of Development and Technological Innovation (EDIT- round VII). The data used classified the firms as innovative or not, where the companies evaluated their innovative performance in an ordinal way. However, the survey only included obstacles to innovation for innovative firms. We tried to mitigate the potential selection bias using a Heckman selection model (Cameron & Trivedi, 2005). Thus, we estimated a model in two stages. First, we considered whether the firm is innovative in a selection equation. Further on, in the second stage, the innovation performance equation contained the drivers and obstacles for 3,298 innovative firms.

The contributions of this article are threefold. First, we offer some elements to expand the discussion about the determinants of innovation performance, focusing on the service sector in the context of emerging markets. While numerous scholars have achieved progress in understanding the determinants of innovation at the firm level, these studies have focused on internal firm mechanisms and skills, paying less attention to how the institutional environment and external collaborative networks can influence or hinder innovation processes in particular sectors and contexts. Then, studying the determinants of innovation performance at the firm level in the service sector aims at contributing to the literature on innovation ecosystems (Roberson et al., 2023), where interactions in the innovation process are supported by different geographical scenarios (Guerrero & Siegel, 2024). It entails different challenges and impacts of various dimensions across industries and contexts (Khaksar et al., 2023); for example, the effect of factors such as open innovation and confidentiality agreements varies between manufacturing and service sectors (Barrios-Aguirre et

al., 2024), and firms across different sectors innovate differently, the effect of innovation intensity on innovation output differs, also indicating different modes of learning (Fuentes et al., 2020).

Second, we applied an appropriate correction model for selection bias because the dataset only captured the innovation performance of those companies that decided to innovate. Following Bending and Hoke (2022), Heckman's two-stage estimation is a powerful method to moderate a possible selection bias highly relevant to entrepreneurship and innovation research. In the same way, this contribution points out that rigorous empirical research should quantify and measure innovation using a valid and reliable instrument based on a theoretical base (Kuckertz, 2017). Thus, we propose an empirical approach based on a theoretical framework grounded in the dynamic capabilities perspective as an extension of the resource-based view and absorptive capacity theory that integrates the variables of the institutional environment, organizational capabilities, cooperation networks, and human capital. This model suggests that the internal disadvantages of firms are reinforced by financial, technological, and regulatory environments that hinder the innovation processes in emerging economies.

Third, we provide empirical evidence for emerging countries that characterize the decision-making planning scenario of firms in which a company decides whether to develop innovative processes, elements that, therefore, can become the focus of the innovation policy that contributes to the achievement of the long-term goals set by an economy, as is the case of the Sustainable Development Goals (SDGs). According to Daronco et al. (2023), several gaps in firm-level innovation capability still need to be studied. One is that "measuring the complexity of organizational IC is imperative for both practice and research" (Daronco et al., 2023, p.245). Following the framework proposed by the dynamic capabilities perspective, our findings consider some mechanisms that firms in the sector of service and in emerging economies could implement. This provides a new direction for both future research and policy formulation that will enable policymakers to create more conducive environments for innovation, particularly in contexts where innovation is essential for sustainable development.

This paper is organized as follows: Section 2 briefly summarizes the literature review about drivers and obstacles to innovative performance and develops the hypothesis. Section 3 introduces the methodological approach, including the data, variables, and statistical estimation. Section 4 shows the empirical findings and discusses them. Section 5 presents the main conclusions and implications. Finally, section 6 offers some limitations and future directions of research.

2 Theoretical framework and hypothesis development

The theoretical framework to identify the drivers and obstacles of innovative performance in the Colombian service sector considers the dynamic capabilities approach as an extension of the resource-based view and absorptive capacity theory. According to the resource-based view, the competitive advantage of a firm is explained by endogenous or internal factors (Barney, 1991) because of both control of strategic resources characterized by value, rareness, imitability, and substitutability, and resource endowments linked with initial conditions that affect subsequent performance (Leiblein, 2011). Another important theoretical foundation of innovation management is the Resource-Based View (RBV) at the firm level. "According to the RBV, the key to achieving a sustained competitive advantage is to develop and exploit valuable, rare, and hard-to-imitate resources and capabilities" (Hafkesbrink & Schaff, 2024, p. 140). Paipa et al. (2024) mention that the Theory of Capacities and Resources examines the innovation process based on organizational characteristics linked to activities, human personnel, knowledge, and artifacts that organizations or systems possess. However, by emphasizing internal resources as the only factor describing the

differences in innovation, the resource-based perspective does not offer a deep understanding of the firm's interaction with its environment (Kaur, 2019).

To provide a broader framework, the dynamic capabilities approach complements the resource-based view by explaining how combinations of internal and external firm-specific competencies and resources can create competitive advantages (Teece et al., 1997). The absorptive capacity theory refers to a firm's capacity to allocate resources for innovative activities, focusing on exploiting internal and external knowledge of prior related knowledge (Cohen & Levinthal, 1990). Following Zahra and George (2002), absorptive capacity is a dynamic capability that influences the firm's innovation performance through acquiring, assimilating, transforming and exploiting knowledge.

From the dynamic capability framework, firm success depends upon the identification and development of opportunities through the effective combination of internally and externally generated inventions, highly efficient technology transfer, the protection of intellectual property, the upgrading of 'best practice' business processes; the invention of new business models; and accomplishing protection against imitation and other forms of replication by rivals (Teece, 2007).

According to the literature review, many factors can drive or hinder innovation performance. On the one hand, Parrilli and Radicic (2021) proposed internal and external STI and DUI driver forces of successful innovation. On the other hand, works as Ortiz and Fernandez (2022) focused on different types of obstacles for companies. We grouped innovation determinants into three components for research: innovation capability or internal resources, external resources, and obstacles.

2.1 Innovation Capability (IC)

Innovation capabilities are widely recognized in the literature. According to Hult et al. (2004), they are one of the critical factors driving innovative behavior at the firm level. Moreover, we adopt the definition given by Daronco et al. (2023), which states that innovation capability is one of the critical internal factors that promote firm achievement, where firms have a collection of organizational characteristics and abilities or mechanisms to begin with.

Prior studies have shown a strong correlation between innovation capability and innovation performance. Indeed, the resource-based view explains the innovative process through the firm's internal factors such as size or debt–tangible factors–human, commercial, and organizational resources–intangible factors–and strategies (Galende & de la Fuente, 2003).

Innovative capability development encourages the growth of organizations (Mone et al., 1998). The main driver of growth and wealth creation is the increase in revenue. In this way, financial performance is a guarantee of innovation, because when a company generates resources, it also promotes its investment capacity (Bayarçelik et al., 2014; Berenguer & Gois, 2018) and resource management (Zawislak et al., 2012) to foster innovative performance. Moreover, a greater target market size requires more significant innovation to ensure the adaptation process.

Innovation shows a company's capacity to adapt to a competitive environment. Thus, the company with a high export propensity should innovate to access new markets (Alegre, 2012; Golovko & Valentini, 2011; Perez et al., 2017). In the business context, an endogenous response to new environments will be the heterogeneity of the exporting basket, which requires innovation (Basile, 2001). Thus, the development of product exporting supports the projected new product development (Filgueiras & Perez, 2010).

Also, several authors focused on knowledge, learning transfer, and organizational learning mechanisms from the perspective of the distinction between STI and DUI innovation modes. In this framework, highly educated and science-oriented human capital is the crucial factor driving

STI innovation, while experience-based human capital, teamwork, and in-company training are essential organizational features for DUI innovations (Parrilli & Radicic, 2021; Santos et al., 2022).

From a dynamic capability perspective, knowledge-related capabilities are drivers of innovation performance at different stages of economic development (Robertson et al., 2023). In addition, knowledge workers play a crucial role in absorptive capacity, and firms must create and apply knowledge from their internal resources, which requires highly skilled workers (Khaksar et al., 2023). More specifically, in the Colombian manufacturing industry, Ramirez et al. (2019) found that the percentage of university workers positively affected SMEs' propensity to innovate.

Considering these reasons, we propose our first hypotheses:

> $\mathcal{H}1$: A greater installed innovative capability boosts the innovative performance at the firm level.

2.2 External resources

External resources refer to collaborations between the enterprise and its environment. In this grouping, we consider relations or interdependencies between different actors engaged in innovation activities and who interact with other entities and businesses, such as university-industry collaborations in the STI mode or clusters and industrial districts in the DUI mode (Parrilli & Radicic, 2021). More specifically, firms can collaborate with specialized innovation agents such as universities and business stakeholders like customers, suppliers or competitors in both DUI and STI learning modes to increase their innovation outcomes (Calvo et al., 2022; Chen et al., 2011; Santos et al., 2022; Zhang & Qi, 2023).

Even though the impact of network relationships on innovation could be ambiguous (Zhang & Qi, 2023), in the dynamic capabilities view, organizations can apply knowledge from both internal and external resources (Khaksar et al., 2023). Furthermore, from a resource-based perspective, firms must acquire resources with partners to compensate for their resource limitations. On the one hand, cooperation with suppliers and customers provides access to relevant information and knowledge about technology and potential needs, which improves a firm's adaptability to the market (Zhang & Qi, 2023). In contrast, failure to realize customer needs or get new technologies can lead to unsuccessful innovation efforts (Shaik et al., 2023). On the other hand, cooperative actions with different actors, particularly in R&D, increase innovative performance (Dinali et al., 2020).

Contracts with the national public sector are a variable that enables the evaluation of relations with the national sector and allows organizations to establish better and lasting contracts. For this reason, it is important that public procurement promotes the efficient management of scarce public resources (Garcia, 2017) or facilitates access to resources. The latter would explain why public procurement is more effective for smaller firms (Aschhoff & Sofka, 2009). Hence, it is important to modernize public procurement systems to increase effectiveness and efficiency in using public resources (Jimenez & Roca, 2017).

The literature on organizational learning, innovation, and internationalization traditionally incorporates the role of international public sector contracts (Chiva et al., 2011). In the same way, Caria (2017) shows that international public procurement affects how companies make contracts so that they develop innovation processes to generate new collaborative relationships. In the Latin American context, Campo and Herrera (2016) state that a country's economic growth depends mainly on its relationship with other countries; meaning that they mutually benefit from the innovation processes abroad.

In sum, knowledge and learning transfer are proposed as STI and DUI innovation drivers due to the importance of R&D investment and collaboration between actors that allow the sharing of technology and transformation in new products or processes (Santos et al., 2022).

In this sense, we develop our second hypothesis:

> $\mathcal{H}2$: External sources and collaborative networks at national and international levels positively impact innovation performance.

2.3 Obstacles

The literature on innovation obstacles focused on organizations' impediments when developing innovation activities (Ortiz & Fernandez, 2022). Even though several classifications exist in the empirical study of barriers to innovation (Martinez-Campos et al., 2023), we grouped the obstacles to innovation performance into information and knowledge, risks, and environment. This classification aligns with the dynamic capabilities approach, which establishes three interrelated capabilities: sensing, seizing, and transformational activities (Teece, 2007).

When considering those organizational aspects that limit innovation, the literature suggests that identifying these factors would allow for determining strategies to promote innovation activities (Jacob et al., 2001; Preissl, 1998). Thus, the first group of obstacles to innovation is formed by information barriers and limitations of internal capabilities, which appear linked to the role of information in reducing internal asymmetries in the firm (Kamasak, 2015) or delimiting an organization's internal capabilities (Berenguer & Gois, 2018). In this sense, fostering innovation requires systems: management information, decision support, and executive information (Abualloush et al., 2016). For example, they require Strategic Information Systems (SIS) in competitiveness (Alshubaily & Altameem, 2017). From the perspective of internal capability formation, as Lawson and Samson (2001) state, for innovation, human capital, and technological knowledge are vital, since the propensity to innovate improves when firms have higher numbers of qualified personnel (Aguila & Padilla, 2010; Borra et al., 2005). Furthermore, technologically competent firms with R&D intensity are more likely to identify new opportunities and provide new knowledge, resources, and capabilities. However, success depends on the companies' ability to integrate new technology (Shaik et al., 2023).

According to the theoretical framework, sensing capabilities denote the ability of an enterprise to identify opportunities and challenges, both within the company and external networks. Thus, access to information and knowledge can create opportunities for companies. At the same time, low investment in research activity, constraints on competitive forces, and a lack of understanding of demand and markets can limit firms' innovation performance (Teece, 2007). Particularly, insufficient internal financial resources, the lack of qualified personnel, and the need for adequate information about technologies and markets are identified as outstanding barriers for firms that hinder decisions to invest in innovation (Martinez Campos et al., 2023).

Although the risks that an innovative firm must face are varied and reduce performance, some researchers highlight a positive incidence of these obstacles associated with risks. A risk can promote the establishment of business networks for the exchange of information that allows faster identification of obstacles and overcoming them (Berenguer & Gois, 2018) or the ability to create innovative work that offers viable and dynamic solutions (Diaz et al., 2015). Moreover, firms perceived that lack of demand had a negative association with R&D investment and activities (Ortiz & Fernandez, 2022). Another aspect associated with risk barriers is the low profitability of an innovation (Ruiz & Mandado, 1989).

For the Colombian case, regarding the obstacles associated with risks, according to the Colombian National Administrative Department of Statistics (DANE - in Spanish, 2021), risks are classified as uncertainty regarding the demand for goods and services, uncertainty regarding the success of project execution, and low profitability of the innovation. In this regard, Gonzalez (2015) states that the main obstacles encountered when carrying out innovation are: a lack of resources, a lack of qualified personnel, uncertainty regarding the demand for innovative services or products, and uncertainty regarding the execution of an innovative technique, among others.

At the same time, seizing capabilities emphasizes a company's ability to capitalize on opportunities by making informed decisions regarding investment priorities and strategic choices. To achieve this, firms must develop business models that account for specific outcomes but may also miscalculate potential risks. This misjudgment can lead to consistent preferences and aggressive decisions that result in investments in low-return projects and hinder innovative activities (Teece, 2007).

Obstacles associated with the environment arise through analyzing organizations--regardless of their innovative potential and performance--as they are members of supply chains, of different markets, and of particular economic, political, social, geographical, and cultural contexts. These factors define the minimum internal and external characteristics needed to develop innovative processes (Gonzalez, 2013).

Lastly, transformational capabilities refer to firms recognizing opportunities and guiding their strategic direction to develop new competencies by allocating resources and adopting new processes to respond to market changes (Huang & Ichikohji, 2024). They also refer to business secrets about the knowledge produced to appropriate its benefits (Ortiz & Fernandez, 2022). In this scenario, management abilities focus on integrating know-how and other intellectual property, being consistent with customer needs and technological opportunities, and with the value of internal resources among firms in the same environment (Teece, 2007).

Thus, we propose the following hypotheses:

> $\mathcal{H}3$: The propensity to innovate is more closely linked to overcoming information and knowledge barriers, risks, and environmental obstacles at the company level.
>
> $\mathcal{H}3a$: Lack of access to information and low internal capabilities hinders the innovation process.
>
> $\mathcal{H}3b$: Firms perceive uncertain demand and undertake risky projects that have a negative impact on their innovativeness.
>
> $\mathcal{H}3c$: Innovation depends heavily on external environmental obstacles.

3 Research Methodology

3.1 Data

This research is based on a sample of 9,304 observations from the Survey of Development and Technological Innovation (EDIT—in Spanish), a micro-anonymized dataset provided by the Colombian National Administrative Department of Statistics (DANE - in Spanish, 2021). It analyses innovative activities of Colombian firms in the service sector between 2018 and 2019.

We used cross-sectional data. The data used consolidated information from 9,304 firms, where 64.6% were classified as not innovative and 35.4% as innovative. In perspective, the decision-making process for enterprises implies that they can decide whether to be innovative or

not; in other words, they can decide to participate in the innovation market. More specifically, the survey gives four definitions for innovation performance plus the case when the firm does not innovate. Table 1 shows the definitions.

Table 1. Types of innovation according to the Survey of Development and Technological Innovation

Innovation performance	Definitions
No innovation	Companies that in the reference period of the survey did not introduce innovations, nor reported having any in process, having abandoned any project, or having the intention of initiating any innovation project to introduce innovations.
Innovation intention	Companies that during the reporting period intended to undertake any project for the introduction of new or significantly improved services or goods and/or the implementation of new or significantly improved processes, new organizational methods, or new marketing techniques
Innovation potential	Companies that reported having an innovation project in process or having abandoned it.
Wide innovation	Companies that in the survey reference period introduced at least one new or significantly improved service or good in the domestic market or within the company or implemented a new or significantly improved service delivery method or organizational or marketing method.
Strict innovation	Enterprises that introduced at least one new or significantly improved service or good in the international market.

Note: The author's elaboration is based on EDIT VII (DANE, 2021).

3.2 Model choice

Considering the survey classified the firms as innovative or not, but it only included information about obstacles to innovation for innovative firms, therefore, a possible selection bias exists. We treat it as a self-selection problem because data on a critical variable—innovation performance—are available only for a subset of the population. The situation occurs because of the outcome of another variable, innovation market participation. In this sense, the enterprises self-select into innovation, so whether we observe innovation performance depends on a firm's decision to innovate. Therefore, the firm's decision to innovate creates a sample with an incidental truncation (Bendig & Hoke, 2022), where, for a subset of the population, companies evaluated their innovative performance in an ordinal way.

Particularly, according to the data, the type of the innovation performance is:

$$\text{inn}_i = \begin{cases} 0 & \text{no innovation} \\ 1 & \text{innovation} \end{cases}, \text{ with } \text{ip}_i = \begin{cases} 1 & \text{intention} \\ 2 & \text{potential} \\ 3 & \text{wide} \\ 4 & \text{strict} \end{cases} \tag{1}$$

In consequence, we assumed the existence of a latent variable: the utility of innovative performance (ip^*), which is not directly observed but can be inferred using another observable variable: categories of the type of innovative performance (ip) (Cameron & Trivedi, 2005). For the *j-th,* the following are considered and observed as determinants of innovative performance

the innovative capability, vector IC_j, the external relationship, vector ER_j, and the obstacles associated with information and capabilities, risk and environment, vectors OIC_j, OR_j and OE_j, respectively. Thus, the regression function for the latent variable innovative performance can be expressed as follows:

$$\text{ip}_j^* = \alpha + \beta_1 \text{IC}_j + \beta_2 \text{ER}_j + \beta_3 \text{OIC}_j + \beta_4 \text{OR}_j + \beta_5 \text{OE}_j + u_j \tag{2}$$

The parameter vectors $\{\beta_k\}_{k=1}^5$ are the core of the identification strategy. However, as the type of innovative performance and the valuation of obstacles are observed only for firms self-classified as innovative, each β_k may be over- or underestimated if given the characteristics of non-innovative firms, these would have perceived a lower utility of innovative performance. In order to correct for this bias in parameter estimation, the selection equation must be incorporated:

$$\text{inn}_j = \gamma + \delta_1 \widetilde{\text{IC}}_j + \delta_2 \widetilde{\text{ER}}_j + v_j \tag{3}$$

Where $\sim$ indicates that some of the vectors must contain variables not included in equation 2, to ensure the correct identification of the vectors δ_1 and δ_2. Conditional on firms self-classifying as innovators, as shown in Figure 1, with equations 2 and 3, thresholds for the latent variable that delimit the probability of obtaining specific innovative performance can be estimated. Firms compare the (dis)usefulness of their innovative performance, and if $ip^* \leq cut_1$ they are classified as intending to innovate. Note that the higher the cut_1, the greater the proportion of firms in this category. For firms where $cut_1 \leq ip^* \leq cut_2$, they are classified as potentially innovative; the higher the cut_2 or the lower the cut_1 utility threshold, the greater the proportion of potentially innovative firms.

Similarly, the cut_2 and cut_3 thresholds operate for innovative firms in a broad sense. Finally, the higher the proportion of broadly innovative firms, the lower the cut_3. Note that, under the assumption of normality, the interpretation of the thresholds requires considering the symmetry of the probability distribution.

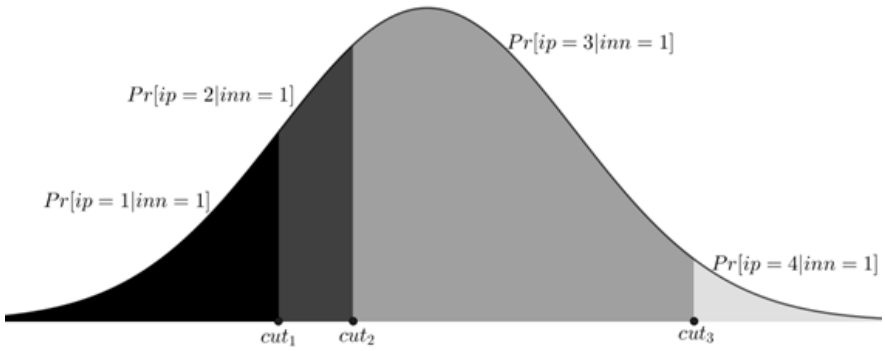

Figure 1. Probability distribution and thresholds of innovative performance.

In this model, the probability of observing each one of the categories for the innovation performance (ip) is defined by the following relation:

$$\begin{aligned} \textbf{Innovation Intention} \quad \Pr(\text{ip}_i = 1) &= \Pr\left(\text{ip}_i^1 < cut_1)\right) \\ &= \Pr(X_i\beta + u_i < cut_1) \\ &= \Pr(u_i < cut_1 - X_i\beta) \\ &= \Phi(cut_1 - X_i\beta) \end{aligned} \tag{4}$$

Innovation potential

$$\begin{aligned} \Pr(\text{ip}_i = 2) &= 1 - \Pr(\text{ip}_i = 1) - \Pr(\text{ip}_i > 2) \\ \text{where} \quad \Pr(\text{ip}_i > 2) &= \Pr(\text{ip}_i^1 > cut_2) \\ &= \Pr(X_i\beta + u_i > cut_2) \\ &= \Pr(u_i > cut_2 - X_i\beta) \\ &= \Phi(X_i\beta - cut_2) \\ \text{then} \quad \Pr(\text{ip}_i = 2) = 1) &= 1 - \Phi(\text{cut}_1 - X_i\beta) - \Phi(X_i\beta - cut_2) \\ &= \Pr(\text{ip}_i = 2) = \Phi(\text{cut}_2 - X_i\beta) - \Phi(cut_1 - X_i\beta) \end{aligned} \tag{5}$$

Wide innovation

$$\begin{aligned} \Pr(\text{ip}_i = 3) &= 1 - \Pr(\text{ip}_i = 1) - \Pr(\text{ip}_i = 2) - \Pr(\text{ip}_i > 3) \\ &= 1 - \Phi(\text{cut}_1 - X_i\beta) - \Phi(\text{cut}_2 - X_i\beta) + \Phi(\text{cut}_1 - X_i\beta) - \Phi(X_i\beta - cut_3) \\ &= \Phi(\text{cut}_3 - X_i\beta) - \Phi(cut_2 - X_i\beta) \end{aligned} \tag{6}$$

Strict innovation

$$\begin{aligned} \Pr(\text{ip}_i = 4) &= 1 - \Pr(\text{ip}_i = 1) - \Pr(\text{ip}_i = 2) - \Pr(\text{ip}_i = 3) \\ &= 1 - \Phi(\text{cut}_1 - X_i\beta) - \Phi(\text{cut}_2 - X_i\beta) + \Phi(\text{cut}_1 - X_i\beta) \\ &- \Phi(\text{cut}_3 - X_i\beta) + \Phi(\text{cut}_2 - X_i\beta) \\ &= 1 - \Phi(\text{cut}_3 - X_i\beta) \end{aligned} \tag{7}$$

Where $\Phi(.)$ denotes the normal distribution function, the functional form adopted in the probit models. An ordered multinomial model was used to determine the profiles of service companies based on their level of innovative performance. This model allows for the qualification of various results in a survey through a cross-sectional approach. Since the dependent variable is discrete, models with limited dependent variables were employed. The innovative performance variable has several alternatives, making it multinomial. An ordered model was used because the dependent variable indicates an order. Innovative performance is considered the dependent variable, is discrete, and represents several mutually exclusive ordinal alternatives. In this case, linear regression is not suitable to explain the peculiarities of this variable as it presents three problems: i) bounding: probability predictions may not be within the range of (0,1); ii) discreteness: the dependent variable is discrete, and the model linear regression is for continuous variables; iii) it violates the assumption of normality in the errors, which is why the variance of the errors is not constant; that is, heteroskedasticity occurs.

The discrete dependent variable models do not use the least squares method for three main reasons. Instead, they solve the problems of delimitation, discreteness, and non-normality using the maximum likelihood method, which involves maximizing the likelihood function. This method offers the advantage of not relying on the assumption of normality in the errors. However, it is worth noting that the estimators obtained through maximum likelihood coincide with those from the ordinary least squares method (Davidson & MacKinnon, 2004). Choice models were used to understand how economic agents make decisions when presented with multiple options. For all the reasons mentioned, an ordered multinomial model was used to establish the profiles of service companies based on their level of innovative performance.

The regressions were performed with robust standard errors, which corrects the possible heteroscedasticity problem. They also include estimates with endogenous covariates, guaranteeing

consistent and efficient estimators. Likewise, given the difficulty in interpreting the estimated coefficients in the ordered probit, the analysis was carried out by calculating the marginal effects. However, the mechanisms may differ depending on the type of innovation. To examine this further, separate estimations were carried out for each type of performance.

3.3 Variables

Of the 9,304 companies in the service sector, we observed the innovation performance of 3,298 innovative firms. The first stage involves running estimations on the entire sample to investigate whether the firm decides to innovate or not. Thus, the selection equation (inn_j) contains the innovation capability IC_j and the external relations ER_j variables. In the second step, we estimated the factors that influence innovation performance. Then, the innovation performance equation includes the obstacles associated with information and knowledge, risk, and environment.

Several variables captured the innovation capability: i) a combination of the sales and exports (*linc*) that represent size (Galende & de la Fuente, 2003) and the access to new markets (Alegre, 2012; Golovko & Valentini, 2011; Perez et al., 2017); ii) financial and organizational resources (Bayarçelik et al., 2014; Berenguer & Gois, 2018; Zawislak et al., 2012) are incorporated by performance indicators (*pind*), ii) knowledge-related capabilities (Khaksar et al., 2023; Ramirez et al., 2019; Robertson, et al., 2023), where we used three proxies: number of workers with labor skills certifications (*swcs*), number of workers with a master (*mas*), and number of workers with a doctorate (*doc*).

In order to measure the impact of network relationships (Khaksar et al., 2023; Zhang & Qi, 2023) and the importance of the public sector (Aschhoff & Sofka, 2009; Garcia, 2017; Jimenez & Roca, 2017), the grouping of external relations included two dichotomic variables with those firms that had business with national public sector (*npsb)* and firms that had business with international public sector (*fpsb)*.

Lastly, the obstacles contained in the innovation performance equation were grouped into information and knowledge, risk, and environment. First, information and knowledge (Martinez Campos et al., 2023; Shaik et al., 2023; Teece, 2007) were captured by Lack of own funds (*I10R1*), Lack of qualified personnel (*I10R2*), Regulatory difficulty (*I10R3*), Lack of information on markets (*I10R4*), Lack of information on available technology (*I10R5*), and Lack of information on public aids (*I10R6*). Second, risk barriers (Berenguer & Gois, 2018; Diaz et al., 2015; Ortiz & Fernandez, 2022; Ruiz & Mandado, 1989; Teece, 2007) were operationalized by Uncertain demand for innovative goods and services (*I10R7*), Uncertain project risk (*I10R8*), and Low rates of return (*I10R9*). Third, regarding environment limitations (Huang & Ichikohji, 2024; Ortiz & Fernandez, 2022; Teece, 2007) we used five proxies: Lack of external financing to the company (*I10R10*), Difficulty in finding innovation partners (*I10R11*), Ease of imitation by others (*I10R12*), Lack of intellectual property system to protect innovation (*I10R13*), and Lack of evaluation and monitoring system (*I10R14*).

Table 2. Definition of variables used in this study.

Variable	Acronym	Definition
Dependent variable		
Innovation	inn	1 = If the firm is innovative 0 = otherwise
Innovative performance	ip	1 = Intention 2 = Potential 3 = Wide 4 = Strict
Independent variables		
Innovation capability (IC)		
Ln(income)	linc	Ln of the firm income (sales + exports)
Doctorate	doc	Number of workers with a doctorate
Master's degree	mas	Number of workers with a master
Certification	swcs	Number of workers with labor skills certifications
Performance Indicators	pind	0 = 0 indicators 1 = one or two indicators 2 = between three or five indicators 3 = between six or nine indicators 4 = ten or more indicators
External relations (ER)		
National public sector business	npsb	1 = firms that had business with the national public sector 0 = otherwise
Foreign public sector business	fpsb	1 = firms that had business with international public sector 0 = otherwise
Obstacles (O)		
Lack of own funds	I10R1	1 = high importance 2 = medium importance 3 = low importance
Lack of qualified personnel	I10R2	1 = high importance 2 = medium importance 3 = low importance
Regulatory difficulty	I10R3	1 = high importance 2 = medium importance 3 = low importance

Variable	Acronym	Definition
Lack of information on markets	I10R4	1 = high importance 2 = medium importance 3 = low importance
Lack of information on available technology	I10R5	1 = high importance 2 = medium importance 3 = low importance
Lack of information on public aids	I10R6	1 = high importance 2 = medium importance 3 = low importance
Uncertain demand for innovative goods & services	I10R7	1 = high importance 2 = medium importance 3 = low importance
Uncertain Project risk	I10R8	1 = high importance 2 = medium importance 3 = low importance
Low rates of return	I10R9	1 = high importance 2 = medium importance 3 = low importance
Lack of external financing to the company	I10R10	1 = high importance 2 = medium importance 3 = low importance
Difficulty in finding innovation partners	I10R11	1 = high importance 2 = medium importance 3 = low importance
Ease of imitation by others	I10R12	1 = high importance 2 = medium importance 3 = low importance
Lack of intellectual property system to protect innovation	I10R13	1 = high importance 2 = medium importance 3 = low importance
Lack of evaluation and monitoring system	I10R14	1 = high importance 2 = medium importance 3 = low importance

The author's elaboration is based on EDIT VII (DANE, 2021).

3.4 Descriptive statistics

First, the innovative capacity considers a set of variables that measure the installed capacity of companies to innovate. Thus, to measure this capacity, the income or national operational sales received by the companies and the exports made by the companies in 2014 were considered, both variables in thousands of current pesos. With these variables, the income received by the companies was calculated (inc=national sales + exports), as well as its logarithm (*linc*). The income thus calculated was reported for innovative and non-innovative firms. This variable allows for the capture of the availability of resources and the size of the firm's market, and, in that sense, it plays a dual role as a determinant of the decision to innovate and as a driver of innovative performance. Figure 1 shows the kernel distribution of the logarithm of revenue for the 9,304 innovating and non-innovating firms reported in EDIT VII. The distribution of innovative firms

exhibits lower kurtosis and looks like a shift to the right relative to the mean of the distribution of non-innovative firms. Both distributions show a high concentration of high-income firms.

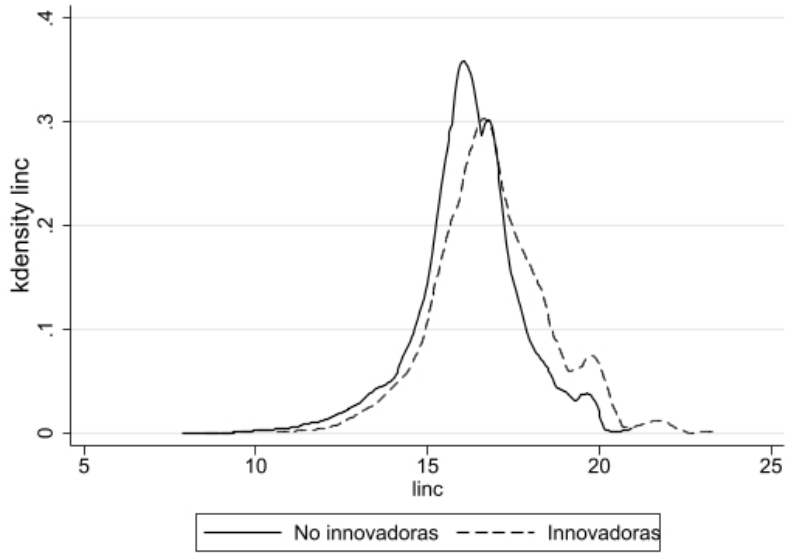

Figure 2. Kernel distribution of the logarithm of revenue.
NOTE: Observations: 9300, $\overline{linc}$ = 16.41275, $\widehat{\sigma}_{linc}$ = 1.61973. Kernel Epanechnikov, bandwidth 0.1838 no innovative, y 0.2701 innovative. Author's elaboration based on EDIT VII.

A second group of variables that capture innovative capacity are the shares of personnel employed in 2018 with a doctoral degree (*doc*), master's degree (*mas*), and labor skills certifications related to the main activity developed by the company (*swcs*). Both innovative and non-innovative companies report the number of personnel with different levels of training, so these variables can be included in the selection equation or as drivers of innovative performance. Table 3 highlights how the share of personnel for these levels of education, doctorate, and master's degree, shows a higher share in the report of innovative companies in EDIT VII.

Table 3. Descriptive statistics of human capital variables

Level of education	No innovative	Innovative
Doctorate	0.09%	0.42%
Master's degree	0.75%	2.51%
Certificate	25.91%	24.29%

Author's elaboration based on EDIT VII.

To evaluate the innovative capacity in terms of management processes, we considered, during 2019, how many key performance indicators (*pind*) the company has. Innovative and non-innovative companies report zero performance indicators (*pind*=0); 1 or 2 indicators (*pind*=1); between 3 or 5 (*pind*=2); between 6 or 9 (*pind*=3); or, finally, 10 or more indicators (*pind*=4). Table 4 shows the greater relative importance of management indicators in innovative companies.

Table 4. Descriptive statistics of management indicators

pind	No innovative	Innovative
0	36,7%	14,0%
1	13,2%	9,1%
2	20,2%	20,2%
3	11,5%	14,7%
4	18,4%	42,0%

Author's elaboration based on EDIT VII.

The second group of determinants of innovation includes external relations, measured through two dichotomous variables: contracts with national public sector entities (*npsb*) or contracts with international public sector entities (*fpsb*). The relative importance of this external relationship metric for innovative companies can be seen in Table 5.

Table 5. Descriptive statistics of external resources variables

	No innovative		Innovative	
	npsb	*fpsb*	*npsb*	*fpsb*
1	21,2%	0,4%	38,2%	2,5%
2	78,8%	99,6%	61,8%	97,5%

Author's elaboration based on EDIT VII.

Finally, obstacles to innovative performance are considered a third group of factors. Only the companies self-selected as innovators evaluated the importance of the obstacles in defining their planning scenarios. Following the theoretical framework, the obstacles to innovation are grouped into three categories.

Firstly, the obstacles associated with internal information and capabilities are associated with innovative companies' perception regarding the scarcity of resources, lack of qualified personnel, difficulties in complying with regulations and technical standards, scarce information on markets and available technology, and public support instruments. Variables are presented in Table 6.

Table 6. Descriptive statistics of information and capabilities obstacles

		Importance level		
Obstacle	Name	High	Medium	Low
Lack of own funds	I10R1	23,01%	40,93%	36,05%
Lack of qualified personnel	I10R2	10,52%	42,75%	46,73%
Regulatory difficulty	I10R3	9,10%	36,66%	54,24%
Lack of information on markets	I10R4	7,88%	38,36%	53,76%
Lack of information on available technology	I10R5	6,43%	38,81%	54,76%
Lack of information on public aids	I10R6	12,12%	33,02%	54,82%

NOTE: Observations: 3298. Author's elaboration based on EDIT VII.

Secondly, the obstacles associated with risks are linked to how innovative firms perceive uncertainty regarding the demand for innovative services, uncertainty regarding the success in the technical execution of the project, and the low profitability of the innovation. Table 7 reveals the relative frequencies.

Table 7. Descriptive statistics of risk obstacles

		Importance level		
Obstacle	Name	High	Medium	Low
Uncertain demand for innovative goods and services	I10R7	17,59%	43,33%	39,08%
Uncertain Project risk	I10R8	13,28%	46,33%	40,39%
Low rates of return	I10R9	13,07%	41,81%	45,12%

NOTE: Observations: 3298. Author's elaboration based on EDIT VII.

Thirdly, the environmental obstacles are focused on capturing the perception of the relative importance assigned by innovative companies to several variables (Table 8).

Table 8. Descriptive statistics of environmental obstacles.

		Importance level		
Obstacle	Name	High	Medium	Low
Lack of external financing for the company	I10R10	17,19%	30,81%	52,00%
Difficulty in finding innovation partners	I10R11	11,58%	34,38%	54,03%
Ease of imitation by others	I10R12	12,13%	33,66%	54,21%
Lack of intellectual property system to protect innovation	I10R13	7,46%	29,99%	62,55%
Lack of evaluation and monitoring system	I10R14	5,79%	31,96%	62,25%

NOTE: Observations: 3298. Author's elaboration based on EDIT VII.

In the different categories of obstacles to innovative performance, the relative importance of scarcity of resources stands out as an obstacle associated with information and internal capabilities, with 23.01% of innovative firms assigning high importance to it. As an obstacle associated with risk, uncertainty regarding the demand for innovative services or goods is significant for 17.59% of the innovative companies. Moreover, 17.19% of innovative companies perceive difficulties in accessing external financing as an obstacle associated with the environment as highly important.

4 Results and discussion

Table 9 presents the results for the ordinal probit and logit models with the selection equation.

Table 9. Innovation estimation results

Variable	Probit		Logit	
	ip	(*inn*)	*ip*	(*inn*)
linc	0,0574** (0,0258)	0,0855*** (0,01)	0,0534** (0,0157)	0,0852*** (0,0098)
npsb	−0,0247* (0,0583)	−0,3392** (0,0313)	0,0007 (0,055)	−0,3384** (0,0313)
fpsb	−0,2262 (0,2218)	−0,4738 (0,1389)	−0,2129 (0,216)	−0,4757 (0,1374)
doc	0,0225*** (0,0085)	0,0354** (0,014)	0,024** (0,0107)	0,0355** (0,0139)
I10R1	0,0940** (0,0442)		0,0978** (0,0418)	
I10R2	−0,1052** (0,041)		−0,1283** (0,0447)	
I10R3	0,0735** (0,0445)		0,0858** (0,0462)	
I10R5	0,1193** (0,0446)		0,141** (0,0488)	
I10R7	−0,0753** (0,0377)		−0,0815** (0,0394)	
I10R10	0,1098** (0,0415)		0,1179** (0,0413)	
I10R13	−0,0927** (0,0447)		−0,0963** (0,0484)	
mas		0,0265*** (0,0043)		0,0263*** (0,0043)
swcs		0,001*** (0,0005)		0,001*** (0,0005)
pind		0,209*** (0,0096)		0,2062*** (0,0095)
cons		−0,7631 (0,332)		−0,7488 (0,3259)
cut_1	−10,047 (0,7642)		−11,088 (0,5269)	
cut_2	−0,574 (0,7739)		−0,6592 (0,5276)	
cut_3	31,805 (0,8753)		32,287 (0,5354)	
Athrho	−0,5658 (0,1435)			
Rho	−0,5122 (0,1058)		−0,5966** (0,0368)	
Observations	3298	9304	3298	9304

Note: Robust standard errors in parentheses. ***p < 0.01; **p < 0.05; *p < 0.10.

From the perspective of the robust specification of the ordered probit and logit models, it is noteworthy that in both specifications, the coefficient rho=corr u,v<0, meaning that the unobserved components that increase performance are negatively correlated with the unobserved components that encourage participation in innovation. Intuitively, this can be explained by the fact that innovation barriers are conducive to creating unobserved industrial cooperation networks for innovation in EDIT, enhancing innovative performance. However, these unobserved barriers in non-innovating firms disincentivize participation in the market for innovations, i.e., the degree of

ambiguity regarding the risks implied by the probabilistic scenarios that delimit the decision to innovate induce a conservative effect (Melo, 2016) on the extent of the market for innovations.

Considering the observed variables that define the selection equation, all are significant at 5%; the innovative capacity variables encourage participation in innovation, as does the external relationship, having national and international public sector contracts boost participation in innovation. These results are consistent with the characteristics of the companies shown in Figure 2 and Table 3 to Table 5.

In terms of correlations, in the two specifications, the indicators of innovation capability are positively related to innovative performance, with coefficients significant at 5%, which allows us to check hypothesis H1. On the contrary, the external relationship indicators correlate negatively with the firm's innovation decision. Even though the coefficients are insignificant in the innovation performance equation, they are negatively correlated and significant at 1% in the selection equation. These findings contradict what has been empirically found by other authors. Thus, we cannot prove hypothesis H2 in the Colombian case.

Apart from the difficulty of complying with regulations and technical standards (I10R3), which is significant at 10%, the obstacles included are significant at 5%. The obstacles, Lack of qualified personnel (I10R2), Uncertainty regarding the demand for innovative services or goods (I10R7), and Lack of an intellectual property system to protect innovation (I10R13) exhibit a negative correlation with innovative performance. On the other hand, the obstacles associated with internal information and capabilities: Lack of own resources (I10R1), Difficulty in complying with regulations and technical standards (I10R3), and Little information on available technology (I10R5), and the obstacle associated with the environment: Difficulties in accessing financing external to the company (I10R10), show a positive correlation.

These results partially support H3, which states that the propensity to innovate is more closely linked to overcoming obstacles. Specifically, human capital and qualified personnel are significant to innovate, in the same line with Lawson and Samson (2001); Borra et al. (2005); Aguila and Padilla (2010), Ramirez et al. (2019), and Khaksar et al. (2023) which analysis indicate that a high proportion of highly skilled employees perform above average in terms of product innovation. Furthermore, our results show evidence that financial constraints are crucial to investment decisions (Ortiz & Fernandez, 2022). However, the findings suggest that the lack of own resources, regulatory difficulty, and lack of information on available technology are positively associated with innovation performance. This result suggests that firms innovate due to pressure from domestic competitors and customers to survive despite the lack of technology (Zhang & Qi, 2023).

The following section estimates the marginal effects to clarify the estimation of these effects and how they induce leftward or rightward transitions in the density of the innovative performance distribution. It also evaluates the statistical significance at each level of performance.

Table 10 presents the estimated marginal effects considering the 3,298 innovative firms in the sector under the specification of the ordered probit model with the selection equation. The marginal effects for the external relationship variables are omitted since they are insignificant.

Table 10. Marginal effects.

Variable	Intention (1)	Potential (2)	Wide (3)	Strict (4)
nc	$-0,00493^{***}$ (0,00256)	$-0,00448^{***}$ (0,00228)	$0,00802^{***}$ (0,00476)	$0,00139^{***}$ (0,00066)
doc	$-0,00193^{***}$ (0,00079)	$-0,00176^{***}$ (0,00071)	$0,00315^{***}$ (0,00142)	$0,00054^{***}$ (0,00034)
I10R1	$-0,00807 * **$ (0,00382)	$-0,00733^{***}$ (0,00345)	$0,01313^{***}$ (0,00654)	$0,00227^{***}$ (0,00166)
I10R2	$0,00903^{***}$ (0,00375)	$0,00821^{***}$ (0,00332)	$-0,0147^{***}$ (0,00666)	$-0,00254^{***}$ (0,00163)
I10R3	$-0,00631^{***}$ (0,00399)	$-0,00573^{***}$ (0,00358)	$0,01027^{***}$ (0,00683)	$0,00178^{***}$ (0,00136)
I10R5	$-0,01025^{***}$ (0,00411)	$-0,00931^{***}$ (0,00367)	$0,01667^{***}$ (0,00744)	$0,00288^{***}$ (0,00179)
I10R7	$0,00647^{***}$ (0,00337)	$0,00821^{***}$ (0,00332)	$-0,0147^{***}$ (0,00666)	$-0,00254^{***}$ (0,00163)
I10R10	$-0,00943^{***}$ (0,00386)	$-0,00856^{***}$ (0,00344)	$0,01534^{***}$ (0,00689)	$0,00265^{***}$ (0,0017)
I10R13	$0,00796^{***}$ (0,00395)	$0,00723^{***}$ (0,00358)	$-0,01295^{***}$ (0,0068)	$-0,00224^{***}$ (0,00163)

Note: Robust standard errors in parentheses; ***p $<$ 0.01; **p $<$ 0.05; *p $<$ 0.10.

In general, if the marginal effect is significant for each level of innovative performance when evaluating the marginal effects, it should be considered that those factors that exhibit a positive correlation (Table 9) reduce the probability mass in the low innovative performances: intention to innovate and potential to innovate. At the same time, they increase the density in the higher performances, innovating in a broad and strict sense, and vice versa when the correlation is negative.

Based on the marginal effects in Table 10, the independent variables used are significant for each innovation performance. Here are the findings: Regarding income, it was found that for every 1% increase in income, the likelihood of a service company's intention to innovate decreases by 0.00493%, potential performance decreases by 0.00448%, while the likelihood of broad innovation increases by 0.00802%, and that of strict innovation increases by 0.00139%. This demonstrates that a higher income flow increases the chances of obtaining new or improved goods and services in national and international markets. The relationship found is similar for the number of employees with a PhD. The more Ph.D. employees a company has, the higher the likelihood of improving innovative performance. Specifically, with each additional PhD employee, the probabilities of intention and potential performance decrease by 0.193% and 0.176%, respectively, while increasing for broad and strict innovation by 0.315% and 0.054%.

Regarding innovation obstacles, for factors such as lack of internal funds, regulatory difficulty, lack of technology information, and lack of external financing, it was found that the lower the importance of these aspects for companies, the greater the likelihood of broad and rigorous innovation. Conversely, for obstacles associated with a lack of qualified personnel, uncertain demand for innovative goods and services, and lack of an intellectual property system to protect innovation, it was found that the lower the importance of these elements, the lower the likelihood of broad and strict innovation of companies.

Conclusions and implications

This article studies the driving forces and obstacles to innovation performance in firms in the service sector in the context of emerging economies. We applied an econometric strategy to present empirical evidence about the role played by innovative capabilities, external relations, and several innovation obstacles. More specifically, we estimated a Heckman selection model in two stages to moderate the potential selection bias caused by the firms' decisions about whether to innovate or not. Thus, we contribute to expanding the existing empirical literature about the determinants of innovation.

The paper found a positive correlation between innovative capabilities and firms' innovative activities in Colombia. The positive link is crucial for firms with more qualified personnel. Thus, we found evidence about human capital being an essential internal resource for innovation. These findings align with the resource-based view focused on the exploitation of internal firm resources. On the contrary, the external relationship with the public sector reduces participation in innovation processes, but there is no evidence that this relationship affects innovation performance. These findings suggest that public funds are barriers to firms' innovation decisions, not drivers. A possible explanation could be given from an institutional perspective, where a weak institutional environment establishes structures that damage the completion of contracts (North, 1990), thus the firms do not have incentives to innovate.

In addition, the identification strategy implemented makes it possible to account for the negative correlation between unobserved factors that encourage innovative performance and those unobserved factors that encourage participation in innovation processes. For instance, contracts with the national or international public sector can be linked, among others, to the distance between academia and industry and the resistance and motivation of workers regarding technological processes (Zartha et al., 2014).

As for the obstacles, while companies assign less importance to obstacles such as the lack of own resources, difficulty in complying with legal and technical regulations, scarce information on available technology, and difficulties in accessing financing external to the company, the obstacles induce a higher probability of obtaining at least one new or significantly improved service or product in the national market or for the company or implementing a new or significantly improved service delivery method or organizational or marketing method. Nevertheless, this phenomenon is induced by the perception other obstacles having greater importance, such as lack of qualified personnel, uncertainty regarding the demand for innovative services or goods, and lack of an intellectual property system to protect innovation, which plays a crucial role in innovation decision.

To sum up, this research offers a practical understanding of the factors influencing innovation performance in the Colombian sector service at the firm level. Indeed, according to Teece et al. (1997), the dynamic capability approach can explain firm-level success and failure. Regarding limitations, we identified obstacles such as a lack of qualified personnel (Martinez Campos et al., 2023), uncertain demand for innovative goods and services, and a lack of an intellectual property system to protect innovation (Teece, 2007) that hinder innovation performance.

Furthermore, our findings have important policy implications on obstacles to innovation in other countries, as Colombia is an upper-middle economy whose economy is based on the service sector. In Colombia, considerable progress has been made in the recognition of the role of science and technology in competitiveness and its impact on the regions in the country's hinterland, the reason for which, in policy, a cumulative learning process is presented (Henao, 2018). However, Colombia needs to develop science further due to low investment. Regarding science, technology, and innovation, Colombia lags behind compared to other countries with similar characteristics (Dinali et al., 2020; National Planning Department [DNP in Spanish], 2019).

The evaluated evidence allows us to insist on and understand the critical role in overcoming some of the institutional barriers that adequate funding to implement organizational and technological products in conjunction with a freight research program focused on intermodal innovation would play (Holguín-Veras et al., 2008).

Despite this, there is a low level of cooperation between Colombian enterprises to share knowledge and transfer technology, where SMEs can scarcely allocate resources to survive in the market or maintain informal innovation activities. This situation is going in a different direction of more development and integrated regions (Dinali et al., 2020).

5 Limitations and future research

Although this study provides insights into the drivers and obstacles to innovation in the service sector in Colombia at firm level, our findings present some limitations. First, the study focuses on the service sector in an emerging economy, so it may not represent different sectors or economies. A comparative study would provide a broad perspective on the determinants of innovative performance and the differences across industries and contexts. Second, the study was conducted using secondary data, where the constructs and variables were measured in a predeterminate way. Even though we emphasized knowledge capabilities and obstacles, future research could generate its survey based on other theoretical constructs. Third, the study used cross-sectional data to establish the correlation between variables and analyze the drivers and obstacles of innovative performance at a single time. Thus, future research should consider the determinants of innovation performance using longitudinal data to provide a more detailed perspective on patterns or changes over time and establish causal relationships among variables. Lastly, this study was conducted thoroughly with a quantitative approach. A mixed methods research approach could provide consistency, reliability, and validation measures, leading to a holistic understanding of the innovation performance phenomena.

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