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## Determinants of business openness in the innovation processes

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### Abstract

The concept of open innovation has achieved special relevance not only as an object of study in academics, but also as a framework for the development of new models of business management. This article explores the determinants of one of the dimensions of open innovation associated with the use of external knowledge for the development of business innovation processes. The analysis is carried out based on the microdata of the Development and Technological Innovation Survey EDIT 2015 - 2016 carried out by Colombia's statistical agency (DANE). To this end, a measure that captures the degree of openness of the company in relation to the use of external sources of information for the development of innovation activities is introduced. Variables related to the technological capabilities of the company, barriers to innovation, and appropriability strategy are considered as possible determinants.

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## 1. Introduction

In recent decades, a body of literature has emerged that establishes that the company cannot innovate alone, and that this activity depends on the interaction with other actors that allow the company to share costs and reduce

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risks. More importantly, these interactions allow for companies to share complementary resources. One of the approaches that has particularly highlighted the aforementioned aspects, and that has had a wide degree of diffusion, is that of open innovation. Chesbrough (2003) defined open innovation as a paradigm that establishes that companies can and should use external knowledge sources to advance technologically.

The literature has addressed the paradigm of open innovation from multiple perspectives and analytical units, such as the individual, the company, the sector, or even the national innovation system. From an extensive review of more than 150 articles, [7] concluded that researchers have employed multiple definitions and approaches for their studies, which generates difficulties in the construction of a uniform analytical framework. Depending on the above, these authors identified that the openness process may comprise an incoming or outgoing information flow, and that this in turn can be a pecuniary and non-pecuniary interaction.

Usually the concept of open innovation is contrasted with closed innovation, i.e. practices in which companies carry out the activities of idea generation, market construction, distribution, services, and finance independently. However, in reality not many companies follow a completely closed strategy; the constant development outside the organization necessitates more open processes. In this sense, more than the distinction between open and closed innovation, business openness should be understood as a continuous process of interaction in which companies can implement different levels of openness based on the degree of importance that external sources of knowledge have for the development of innovations.

As mentioned above, the lack of a uniform analytical framework has given rise to the implementation of different constructs that conceive the concept of open innovation in different ways. A recently used practice has been to address the analysis of this subject by using the data derived from the innovation surveys applied in many national contexts and based on the guidelines presented in the OSLO manual (OECD, 2005). In this line, the contributions made by [11] are highlighted, who employed the information derived from the National Innovation Survey in the United Kingdom. In this work, the authors approached the study of business openness through the analysis of external sources of knowledge employed by British companies in their innovation processes, distinguishing between two key constructs: breadth (number of external sources used) and depth (number of external sources considered to be of high importance for innovation processes). The results showed that there is a high correlation between the breadth and depth search through various channels and the capture of ideas that generate returns to the company through the exploitation of innovations.

This article aims to explore the determinants of the degree of business openness for the development of innovation activities in the context of the Colombian manufacturing industry. This analysis is interesting when considering most of the investigations carried out to date have been addressed from the consideration of intensive technology sectors in developed countries ([8]); little has been done in less technologically dynamic contexts. In addition, identifying the factors that affect the degree of openness constitutes a topic of special importance from the perspective of business management, particularly when considering that in these contexts the companies have a greater need to resort to external sources of knowledge given their internal technological weaknesses.

In the literature there are several works that have explored the factors, both at the firm and sector levels, that influence the company's adoption, to a greater or lesser degree, of an open strategy for the development of their activities of innovation. With regard to business factors, the most analyzed aspects have been the size and efforts in carrying out internal R&D activities. In general terms, the literature is not conclusive with respect to the effect of these two factors. In relation to size, for example, some studies argue the idea that openness is more relevant to large companies, considering the greater availability of complementary resources and capabilities that they own, and therefore facilitate the search of partners and the management of collaboration agreements [15]. However, there are other studies that argue that due to the lack of internal resources, small businesses have a greater need to be open to the environment to develop their innovation activities [12]. For these companies, the use of external knowledge constitutes a strategic element because they do not have the necessary capacities in solitary projects and are more vulnerable to aspects like the uncertainty of innovation projects and the high probability of failure associated with them.

With respect to business efforts in R&D there are also contradictory visions. One of the most widespread arguments, especially since Cohen and Levinthal proposed the concept of absorptive capacity, is that which establishes a positive relationship between internal R&D efforts and the degree of business openness. According to [6], internal R&D not only contributes directly to the development of new products and processes, but also allows the company to develop internal capabilities that facilitate access to external sources of knowledge and their

corresponding economic exploitation in terms of innovations. However, some authors maintain that from the perspective of the resource and capabilities approach, companies with highly developed R&D capabilities can benefit from internal scale economies, which makes it less necessary for them to rely on the participation of external partners in their R&D processes [2].

As seen in the previous paragraphs, the logic behind open innovation falls on the possibility that this strategy offers in terms of accessing complementary external resources. These resources can be knowledge resources, but also financial resources. The use of external sources of information, or collaboration with external actors, can be relevant to reduce the costs of innovation processes by allowing the company to access a market for knowledge and technology under more advantageous economic conditions compared to internal development ([3]). Likewise, open innovation can contribute to reducing the barriers associated with the uncertainty of innovation processes that derive from potential changes in the environment in terms of market and technology. The uncertainty of the market refers to the fluctuations and unpredictability of demand; technological uncertainty is related to the inability of the organization to rightly predict technological requirements [16]. Some authors point out that although uncertainty can increase the costs of external development, the flexibility granted by cooperation or external technology acquisition can compensate for this increase [10]. Thus, for example, the uncertainty that is generated as a product of the speed of technological change can make the company find internal development a less attractive strategy for the development of its innovations given the high probability that internal capacities remain obsolete. For companies that face a high technological uncertainty, cooperation with external agents and the use of external sources of knowledge can become an important mechanism to access complementary resources and knowledge that will help them introduce products in the market with greater speed [13].

In addition to the above aspects, another factor that has been related to the degree of openness has to do with the appropriability strategy implemented by the company. This strategy is associated with the capacity of companies to capture the benefits derived from their efforts in innovation, reducing the filtrations of information and knowledge to other market players as much as possible. In the current literature on open innovation there is no consensus on the relationship between appropriability and the level of business openness. On the one hand, it is highlighted that the greater the importance the company attributes to the conditions of appropriation within the business strategy, the lower its level of openness [11]. In this sense, the indication is that firms that overprotect their knowledge base are more likely to lose opportunities to exchange valuable knowledge with different actors. On the other hand, some authors argue that the degree of appropriation existing in an industry can favor an organization's level of openness [4]. For example, the existence of strong legal protection mechanisms increases the confidence of business managers in the adoption of knowledge transfer mechanisms with external agents.

In addition to the aforementioned business characteristics, a series of factors associated with sectoral dynamics have been analyzed in the literature as possible determinants of the degree of business openness. Among these factors, the technological intensity of the sector in which the company operates is highlighted. In this sense, some authors highlight the benefits of implementing an open innovation strategy in sectors cataloged as high-tech [14]. The above because in these sectors there is usually a higher level of technological opportunities that encourages companies to perform a wider and more profound search in order to gain access to resources that are critical for the development of innovation processes.

### **3. Methodology**

#### *3.1. Data and variables*

For empirical analysis, data from the Technological Development and Innovation Survey (EDIT) of the Colombian manufacturing industry between the years 2015 and 2016 carried out by the National Administrative Department of Statistics (DANE) were used. The EDIT aims to investigate the development and technological innovation activities advanced by industrial companies in Colombia with personnel greater than or equal to 10 people.

The survey collects data from 7947 companies. However, the detail of the survey in questions related to aspects of innovation conditions the possibility of companies that are not considered innovative, or that still do not have a clear innovation dynamic, responding to all of the questions. This work focuses on 2237 records of manufacturing companies that have all the registers needed to address this analysis. Therefore, the analysis of censored data

required the implementation of an approach to avoid sample selection bias. In particular the econometric analysis used a two stages Heckman's model. If the main model were directly estimated the inference would be wrong, since the target equation estimators would be inconsistent. Subsequently, it is incorporated into the main regression model, which in this case follows a negative binomial regression model due to the characteristics of the dependent variable.

Table 1 shows the definitions of the variables used in econometric models. The dependent variable in the study is the degree of business openness. Following the strategy used in previous investigations [11], this variable has been defined considering the use of external agents as a source of information for the development of business innovation processes.

Table 1. Definition of descriptive variables and statistics

Variables	Description
GRAPER	Measures the company's degree of openness in the 2015-2016 period. It is a count variable that takes positive integers from 0 to 15.
INTID	It represents the investment in R&D of the total invested in innovation activities in 2015.
TAM	Number of employees of the company in 2015.
SECT	SECT0 (low technological intensity sectors); SECT1 (Medium technological intensity sectors) SECT2 (Medium-high technological intensity sectors); SECT3 (high technological intensity sectors)
BAR_COS	Assessment of a number of factors, such as obstacles to the development of innovation activities. A composite indicator was calculated considering the following factors: shortage of own resources; difficulties in accessing external financing. Cronbach's Alpha 0,71
BAR_CON	Assessment of a number of factors, such as obstacles to the development of innovation activities. A compound indicator was calculated considering the following factors: lack of qualified personnel, scarce information on markets, scarce information on technology. Cronbach's Alpha 0,79
BAR_INC	Assessment of a number of factors, such as obstacles to the development of innovation activities. A composite indicator was calculated considering the following factors: uncertainty against the demand for goods and services; uncertainty against the technical execution of the project. Cronbach's Alpha 0,79

Source: the authors

#### 4. Results and Discussion

Table 2 presents the results of the main model with the inclusion of the inverse Mills' ratio to control for the potential selection bias. With respect to business features, the results show (see Table 2) that size exerts a significant and positive effect on the degree of openness of the company. This result is consistent with the arguments raised in previous studies that indicate that large companies, due to their greater availability of resources, can implement a more open strategy as regards the use of external sources of knowledge.

On the other hand, the variable that reflects internal R&D efforts (INTID) has no significant effect. Despite this, it is necessary to emphasize that the variable that measures the technological intensity of the sector in which the company operates does play a decisive role in the definition of its degree of openness, although to a certain level. Compared to the low-tech intensive sectors (category used as reference), the medium-low (SECT1) and medium-high (SECT2) sectors are more likely to use a greater number of external sources of knowledge in their innovation processes. However, belonging to a sector cataloged as high-tech (SECT3) does not show a significant effect. In part, this result is in line with what is indicated in previous studies that have linked greater sector technological intensity with a greater use of external sources of knowledge. However, it also indicates that for the case of the more advanced sectors it is possible companies may have a lesser need to externally seek knowledge, or that they may have greater difficulty finding sources that offer them complementary resources. Therefore, their degree of openness is lower when compared to lower technological intensity sectors.

The above results can also be understood in the light of what has been proposed by [1] in their study on the Spanish case. This author, through the distinction of three openness levels (open, semi-open and closed) noted that the effect of size and intensity in R&D on the degree of business openness is determined by two aspects: absorptive

capacity and the need for knowledge. In this way, very small and non-intensive companies in R&D, despite having a great need for external knowledge, lack the absorptive capacity necessary to benefit from a collaborative agreement with external agents. In this case, companies opt for a closed strategy. Conversely, large companies and companies with high intensity in R&D have a large ability to absorb, but a lower need to resort to external sources. These companies therefore resort to a semi-open strategy in which they continue to base their innovation processes in their internal technological capabilities, even though they capture certain information from the environment. Finally, it is the companies with a medium intensity in R&D that - in our case it could be associated with belonging to sectors of medium and high technological intensity - tend to base their innovation processes in the use of external sources of knowledge (open strategy) because they combine two key factors: they have a level of absorptive capacity that allows them to exploit the knowledge that other agents have, and they have the need to resort to external sources because they do not have sufficient technological capacities to advance innovation processes by themselves.

Regarding the variables associated with the barriers for innovation, the results show that uncertainty barriers (BAR\_INC) and knowledge barriers (BAR\_CON) have a significant and positive effect on the degree of openness, while cost barriers (BAR\_COST) turned out to be non-significant. This result suggests that in the analyzed context the degree of openness in innovation processes is more associated with the possibility of accessing knowledge and complementary information that reduces barriers derived from the lack of self-knowledge or uncertainty (both market and technological), than with the reduction of innovation costs.

Table 2. Model Results

Independent Variables	Openness Degree (GRAPER)	
	Coefficient	Standard Error
Constant	0.34055	0.43383
INTID	1.74626	0.96980
TAM	0.09615*	0.04802
SECT1	0.16934 **	0.06376
SECT2	0.18233 **	0.06755
SECT3	0.04187	0.13425
BAR_CON	0.26028 **	0.05744
BAR_COST	0.09271	0.05679
BAR_INC	0.17877 **	0.05733
RDI	-0.11551	0.25472
RMS	0.22388 **	0.07227
PAT	0.24838	0.21376
DA	0.26872	0.32028
MEST	0.22155 ***	0.05403
INVMILLS	-0.57477 **	0.21227
No. Observations	2237	

Source: Calculation of the authors

As far as the company's appropriation strategy is concerned, two variables have a significant and positive effect: the use of registered trademarks (RMS) and the use of strategic protection mechanisms (MEST). In general, these results show that companies that implement strategies to protect the results of their efforts in innovation and appropriate the benefits derived thereof as much as possible tend to be more open to the use of external sources.

## 5. Conclusions

Open innovation has become a relevant approach to the analysis of business innovation processes. Its importance is much greater in the context of developing countries where companies possess few internal capacities and can hardly carry out innovation activities without resorting to collaboration with external agents, or to the use of

available knowledge in their environment. In this sense, the analysis of the factors that influence adoption by the company of an open innovation strategy constitutes an interesting aspect, not only from the academic perspective, but also in the field of business management.

This article has explored this phenomenon taking the Colombian manufacturing industry as a case study. Within the set of possible determinants of the degree of openness, the study has considered internal company factors, as well as characteristics of the sector in which the company operates. In general, the results show that the size significantly influences the degree of openness of the company. In this sense, although small and medium-sized companies can have a major marginal benefit when opening their innovation strategies, it is likely that their limited resources prevent them from seeking and accessing a greater diversity of sources of information. Likewise, the results suggest that, in the analyzed context, companies implement an open innovation strategy to correct the internal weaknesses in the field of knowledge or barriers associated with the uncertainty of innovation processes, but not in order to solve the problems related to the costs of said processes. In other words, openness is fundamentally seen as a process to access knowledge resources, either for the development of innovation or its technological and commercial validation, but not so much as a strategy for decreasing costs.

Finally, the results show that to the extent that companies perceive that there are scarce third-party imitation possibilities, they tend to employ a greater number of external sources of knowledge. On the contrary, when it is difficult to protect its results, the company tends to resort less to external agents, perhaps with the aim of avoiding involuntary information leaks, or that third parties come into contact with relevant knowledge.

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## References

- [1] Barge-Gil, A. (2011). Open, Semi-Open y Closed Innovators: Towards an Explanation of Degree of Openness, *Industry and Innovation*, 17 (6), 577-607.
- [2] Cassiman, B. and Valentini, G. (2009). Strategic organization of R&D: The choice of basicness and openness, *Strategic Organization*, 7 (1), 43-73.
- [3] Chesbrough, H and Bogers, M. (2014). *Explicating Open Innovation: Clarifying and Emerging Paradigm for Understanding Innovation*. Oxford University Press, 3-28.
- [4] Chesbrough, H. (2006). *Open Business Models: How to Thrive in the New Innovation Landscape*. Harvard Business School Press.
- [5] Chesbrough, H. (2003). The era of open innovation, *Sloan Management Review*, 44 (3), 35-41.
- [6] Cohen, W. and Levinthal, D. (1990). Absorptive capacity: a new perspective on learning and innovation, *Administrative Science Quarterly*, 35 (1), 128–152.
- [7] Dahlander, L and Gann, D. (2010). How open is innovation? *Research Policy* 39. 699–709.
- [8] Ghisetti, C., Marzucchi, A. and Montresor, S. (2015). The open eco-innovation mode. An empirical investigation of eleven European countries. *Research Policy*, 44, 1080–1093.
- [9] Heckman, J. (1979). Sample Selection Bias as a Specification Error. *Econometrica*, 47 (1), 153-161
- [10] Klein, K. J., Hall, R. J., and Libberte, M. (1990). Training and the organizational consequences of technological change: A case study of computer-aided design and drafting. En: U. E. Gattiker & L. Larwood (Eds.), *Technological innovation and human resources: End-user training*, 7-36. New York: de Gruyter.
- [11] Laursen, K. and Salter, A. J. (2014). The paradox of openness: appropriability, external search and collaboration. *Research Policy*, 43 (5), 867-878.
- [12] Nieto M. J. and Santamaría L. (2010). Technological Collaboration: Bridging the innovation gap between small and large Firms. *Journal of Small Business Management*, 48 (1), 44–69.
- [13] Steensma, H., Marino, L., and Weaver, M. (2000). Attitudes toward cooperative strategies: a cross-cultural analysis of entrepreneurs, *Journal of International Business Studies*, 31 (4), 591–609.
- [14] Tödting, F., Lehner, P., and Trippel, M. (2006). Innovation in Knowledge Intensive Industries: The Nature and Geography of Knowledge Links. *European Planning Studies*, 14, 1035-1058.
- [15] Veugelers, R. (1998). Collaboration in R&D: an assessment of theoretical and empirical findings. *De Economist*, 146 (3), 419-443.