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Consequences of open innovation: effects on skill-driven recruitment

Abstract

Purpose

This paper focuses on the human side of inbound open innovation by analysing the effects that the adoption of different knowledge search strategies for innovation has on new recruitment needs.

Design/methodology/approach

Building on several theoretical perspectives, the study proposes three hypotheses regarding the relationship between openness and the need to recruit people with high technical and social skills. Using a pooled panel data from the Uruguayan Innovation Survey between 2004 and 2012 we identify open strategies followed by the firm.

Findings

The estimation results using pooled panel data and panel data techniques confirm that the adoption of open search strategies for innovation demands the recruitment of new employees with higher technical and social skills. Technical skills are more likely to be demanded than social skills. The effects observed are higher when the firms use intensively knowledge and information sources.

Originality/Value

This paper revisits the analysis of specific knowledge search strategies at the firm level. In doing so, the study looks for the effects of specific strategies combining different knowledge sources and considers different levels of use of external KISs, from narrow to wide. While other studies have analysed the human factor as a determinant of the success of openness for innovation, this paper re-examines the direction of this relationship. Finally, the study contributes with evidence from a Latin American country, where these topics have received less attention.

Keywords: Open innovation, social skills, technical skills, recruitment

Paper type: Research paper

1. Introduction

In the last decade, researchers have highlighted the role of open innovation as a key driver of innovation performance (Laursen and Salter, 2006; Bogers *et al*., 2018). Hence, infrastructures and antecedents for firms' effective and efficient innovation openness have received considerable attention in the literature (Leiponen and Helfat, 2010; de Araújo Burcharth *et al*., 2014).

Studies in the field have observed greater complexity of complementary knowledge search strategies aimed at enhancing innovation performance (Grimpe and Sofka, 2016), increasing both the search *breadth* (number of sources) and the search *depth* (intensity of use) of knowledge and information sources (KISs) (Laursen and Salter, 2006). In this context, the "human side" of open innovation has increasingly been recognized as a determinant of the capture and integration of both external and internal sources of knowledge (Bogers *et al*., 2018; Criscuolo *et al*., 2018). New sets of technical

and social skills and backgrounds are required from the firm's workforce (Petroni *et al*., 2012; Salge *et al*., 2013), among other things to improve searching (Dahlander *et al*., 2016) and to establish collaborative communication, encouraging the development of relationships with external actors (Pemartín *et al*., 2018).

From Cohen and Levinthal (1989), it is known that innovation success depends on the ability to acquire, absorb and exploit new knowledge. However, inter-organizational knowledge flows do not materialize automatically, and firms need to acquire or develop new skills to explore and exploit new external sources of information and knowledge (Eisenhardt and Martin, 2000; Vanhaverbeke *et al*., 2008). In this sense, this study focuses on the organizational consequences of adopting different open innovation strategies, paying special attention to the new need to recruit people with high technical and social skills to manage complex combinations of KISs. On this line, Ter Wal *et al*. (2017) stated that, in the long run, the relationship between skills and innovation strategies is circular: new skills are necessary to innovate and innovation requires new skills. In addition, there has been growing interest in the "dark side" of open innovation, attending to the costs of and barriers to adopting open innovation strategies (Katila and Ahuja, 2002; Villena *et al*., 2011; Laursen and Salter, 2014; Greco *et al*. 2019). However, until now, the evidence concerning the relationship between open strategies and skill-driven recruitment of people has been very limited (Stanko *et al*., 2017).

This paper elaborates a theoretical reasoning to hypothesize how the use of different KISs affect firms' recruitment needs. The process of open innovation is complex and dynamic, and no isolated theoretical perspective is able to explain fully the entirety of its organizational effects (Remneland-Wikhamn and Knights, 2012). As a result,

different approaches need to be considered to understand the organizational effects of adopting different openness strategies (Bogers, 2012; Greco *et al.*, 2019).

According to the literature on open innovation and strategic human resource management (HRM), the association between openness and new demands for recruiting people is controversial (Vanhaverbeke *et al*., 2014). On the one hand, adopting open innovation strategies enables firms to develop effective competitive strategies without requiring numerous and varied, or even any, employees working in research and innovation (Chesbrough, 2006). However, firms that engage in open innovation may need to incorporate new technical and social skills to improve their searching, communication and adaptation to team working (Hillebrand and Biemans, 2004; du Chatenier *et al*., 2010; Salge *et al*., 2013). Companies that are involved in openness strategies may increasingly demand employees with competences and abilities to manage both inside-out and outside-in open innovation flows (Chiaroni *et al*., 2011; Clausen, 2013; West and Bogers, 2014). Through recruitment, firms can access unique ideas and insights (Bogers *et al*., 2018) as well as technical skills and backgrounds, improving the search for, selection and assimilation of new information and knowledge from different actors for both inbound and outbound open innovation (Lichtenthaler and Lichtenthaler, 2009; Clausen, 2013; West *et al*., 2014).

In sum, this paper aims to contribute to the current literature on the "human side" of open innovation by answering the following questions:

- Are open innovation strategies associated with new recruitment needs for technical and social skills?
- Does different open innovation strategies explain different needs of skills-driven recruitment?

Empirically, the hypotheses are tested using pooled panel data of 1,466 firms in the manufacturing and service sectors using the Uruguayan Community Innovation Survey covering the 2006–2012 period.

This paper contributes to the literature on the human side of open innovation in several ways. Firstly, it revisits the analysis of specific knowledge search strategies at the firm level. Rather than just following the studies on the *breadth* and *depth* of openness, the study also looks for the effects of specific strategies combining different sources (Backfisch, 2014; Criscuolo *et al*., 2018). As an extension, the study considers different levels of use of external KISs, from narrow to wide. Second, in contrast to other studies that have analysed the human factor as a determinant of the success of openness strategies for innovation (Lippitz *et al*., 2017; Bogers *et al*., 2018), this paper re-examines the direction of this relationship, considering that openness in innovation may determine the need for more skilled workers. Hence, it approaches the consequences and challenges of open innovation. Finally, the study is undertaken in a Latin American country. While there has been a call for open innovation research in non-Western settings (Cheng and Huizingh, 2014), very few studies have analysed aspects related to open innovation in Latin America (Chaston and Scott, 2012; Arruda *et al*., 2013). Most of those have been case studies (Rodrigues *et al*., 2010; Ades *et al*., 2013) or have analysed the productive strategies in specific economic activities (Brenes *et al*., 2014; Ramos *et al*., 2018) rather than studying the open innovation phenomenon on an economy-wide basis. While this is a limitation when generalizing the empirical findings of this study to other regions, the empirical evidence of this study is a contribution in itself.

2. Theoretical Framework

The relationship between workforce skills and innovation has received the attention of the literature on different analytical levels (Freel, 2005; Tether *et al*., 2005; Deming, 2017). Workforce skills for innovation are a combination of education, talent and experience (Thether *et al*., 2005). Different types of skills are critical to the success of innovation strategies (Ter Wal *et al*., 2017). Sousa and Rocha (2019) identified three critical skills for innovation in the digital IT industry: innovation, leadership and management, that included technical knowledge and social skills linked with communication, networking or talent management. In addition, Ter Wal *et al*. (2017) stressed the dynamics between skills and innovation, suggesting that new skills are required to assimilate new external knowledge and remain innovative.

The paper elaborates on how different search strategies affect the demand for new technical and social skills at the firm level. It defines technical skills as those abilities associated with a formal qualification with a technical or scientific background. These are the result of formal training and experience expressed as the technical capacity to solve relevant problems for the firm (Freel, 2005; Deming and Kahn, 2018). On the other hand, social skills are defined as cooperation and communication abilities, which are potentially related to formal education but are mainly based on personal features and grounded by experience in different contexts (Freel, 2005; Deming, 2017).

2.1 Open Innovation and New Recruitment Needs: Hypothesis Statements.

The degree of openness is a strategic decision resulting from the firm's balance between costs and benefits of more or less openness (Felin and Zenger, 2014). The transaction cost theory (TCT) states that firms begin to organize their production processes internally when the transaction costs of coordinating production using market mechanisms is greater than doing so within the firm (Williamson, 1981). The open

innovation approach is closely related to the TCT with respect to the way in which firms set their boundaries and the extent to which knowledge flows through firm boundaries (Chesbrough, 2003). However, the perspective of TCT has been somewhat neglected in the literature of open innovation along with the study of the interactions of firms with external sources of KISs (Greco *et al*., 2019). The success of open strategies depends on the associated transaction costs of searching and controlling in a process that is interactive in nature (Faems *et al.* 2010) and in which the contact between different actors is more or less formalized (Baldwin and Von Hippel, 2011). The existence of hidden costs of communication, control, evaluating information and bargaining associated with innovation openness (Stuermer *et al*., 2009) can limit the effectiveness of the opening innovation process (Laursen and Salter, 2014; West and Bogers, 2014). Hence, technical skills and the background of the firm's workforce are critical to the cost of searching for valuable knowledge (Köhler *et al*., 2012) and for the transaction cost when firms manage a high variety of external sources (Laursen and Salter, 2014).

In addition, the transaction cost of a firm's openness strategy will depend on the cognitive distance between the firm and each external KISs (Nooteboom *et al*., 2007; Criscuolo *et al*., 2018). Integrating cognitively distant actors may offer new knowledge and innovativeness, but may increase the cost relating to searching, exploring new markets and coordinating different sources (Lichtenthaler and Lichtenthaler, 2010; Criscuolo *et al*., 2018). With this regard, it has been demonstrated that combining a wide number of sources of knowledge, including cognitively distant actors, could be detrimental to firm success (Das and Teng, 2000). Asimakopoulos *et al*. (2019) confirmed an inverted U-shaped relationship between innovation outputs and openness, suggesting an increasing transaction cost when adopting more complex and integrative strategies (Laursen and Salter, 2014). As a result, adopting integrative strategies involving

cognitively distant actors may demand new skills (social and technical) to manage the opening process in the best way.

An important element to consider when assessing the effects of expanding the number of KISs is the absorptive capacity of firms. According to the absorptive capacity view (Cohen and Levinthal, 1989), the effectiveness of exploration and exploitation of new KISs require a set of skills to transfer knowledge and to assimilate and modify this imported knowledge (Zahra and George, 2002). The adoption of open innovation processes can be developed and supported only if companies possess their own competences to assimilate external knowledge (Dahlander and Gann, 2010; Clausen, 2013). In this context, human resources become a strategically critical asset of organizations (Grant, 1996) for developing open innovation strategies (Gomez-Mejía *et al*., 2004; Herstad *et al*., 2015), which in turn may increase the need to recruit highly qualified staff to capture and manage new information and knowledge (Fawcett *et al*., 2012; Criscuolo *et al*., 2018). If not, firms may not be able to follow the open approach to innovation (Clausen, 2013).

Based on this reasoning, we propose the following hypothesis:

H1. The new recruitment needs for both technical and social skills increase with the number of KISs combined in open innovation strategies.

Regarding the effects of the intensity of the use of KISs on new recruitment needs, researchers have related the "depth" of open innovation strategies with higher levels of absorptive capacities (Laursen and Salter, 2006). Absorptive capacity is related to prior skills and knowledge, and is cumulative since its development in the present will permit its more efficient accumulation in the future (Vega-Jurado *et al*., 2008). It can be

developed internally or acquired, for instance by hiring new personnel or contracting consulting services, but, in general, both happen simultaneously (Christensen, 2006).

The depth of openness is determinant to sustain a pattern of interaction with external agents over time, allowing building shared meanings and trust (Ferreras-Méndez *et al*., 2015). However, developing one's own skills and capabilities to implement open innovation strategies implies time and effort, and individuals have limited amounts of time and attention available to perform their daily tasks (Ocasio, 1997). Therefore, new recruitment of external sources can be a determinant of the avoidance of employees working deeply on too broad a range of activities related to searching for and assimilating KISs, as they may struggle to allocate their time effectively across these tasks (Dahlander *et al*., 2016). Thus, the recruitment of workers with higher technical and social skills will contribute to enhancing the capacity of a firm to interpret and transmit acquired knowledge within the organization (Bishop *et al.*, 2011). Ebers and Maurer (2014) stated that individuals will only be able to advance in developing strong and trusted external or internal ties, if they possess the appropriate social skills, which are determinant to establish specific norms for in-depth cooperation (Hillebrand and Biemans, 2003). We propose the following hypothesis:

H2. The new recruitment needs for both technical and social skills increase with the intensity of use of KISs combined in open innovation strategies.

The demands for technical and social skills associated with open innovation strategies depend on the company's opening stage, from unfreezing, when external KISs

are rather marginal, to institutionalization, when innovators rely heavily on external sources (Chiaroni *et al*., 2011).

Assessing the depth of firms' contents from different sources, especially in companies that institutionalize open innovation, not only demands technical capabilities but also social skills to manage strategies integrating broad and varied knowledge from close and distant sources (Criscuolo *et al*., 2018).

As a result, establishing an open innovation strategy usually involves looking for new technical skills and capabilities (Hall and Bagchi-Sen, 2007); however, employees on inter-organizational boundaries should be able to exchange information in an effective manner between organizational groups, which demands a minimum of technical skills (Ancona and Caldwell, 1992). This suggests the existence of differences in the relevance of different skills (technical and social) according to the openness strategy. In this sense, Du Chatenier *et al*. (2010) identified three main tasks required for professionals involved in work teams to develop open and integrative innovation projects effectively: managing inter-organizational innovation, managing the overall innovation process and creating knowledge collaboratively. According to this study, brokering solutions involving high technical skills is the most important competence for professionals working in open innovation projects integrating KISs. This study also highlighted that being socially competent is important to manage diverse KISs. Aligned with this, Petroni *et al*., (2012) stated that high technical–scientific skills of employees and a strong technical knowledge base are determinants of the adoption of advanced open innovation strategies that combine broad and varied knowledge from different sources.

Regarding social skills, it has also been stated that implementing open innovation strategies will demand specific communication (Hillebrand and Biemans, 2004) and teamwork skills (Maltz and Kohli, 2000). On this line, Jansen *et al*. (2005)

stated that exploring and assimilating KISs require both coordination and socialization capabilities. Relatedly, Lindegaard and Kawasaki (2010) showed that social skills based on attitudes and interpersonal abilities are a determinant of being embedded in a dense network of interactions (Laursen and Salter, 2006).

Based on this reasoning, we propose the following hypothesis:

H3. Technical skills are likely to be demanded for all open innovation strategies (from low to high use of KISs), while social skills are likely to be demanded for high and intensive use of KISs.

3. Methodology

3.1 Data

The data set used in this study was built by aggregating three waves of the Uruguayan Innovation Survey (UIS), which cover the period between 2006 and 2012. The surveys contain cross-sectional data on Uruguayan firms, and they are representative of manufacturing and 8 Uruguayan service sectors, considering firms with 5 or more employees. The sampling method combines random sampling of firms with fewer than 50 employees with the compulsory inclusion of larger firms. The authors were able to build panel data due to the identifiers provided by the National Agency of Research and Innovation of Uruguay.

Using innovation survey data raises some methodological issues and presents pros and cons regarding other sources of information about innovation at the firm level. Some criticism of innovation surveys points out that the data are self-reported, which may lead to unobservable biases (Mairesse and Mohnen, 2010). However, self-reported data allow researchers to address some specific information that cannot be captured using only

administrative records. For example, the number and type of KISs used by a firm is not available in any records except for case studies. Moreover, innovation surveys based on the *Oslo Manual* (Organisation for Economic Cooperation and Development (OECD), 2005) guidelines are explicitly oriented towards capturing the actions that the subject (firm) conducts to innovate. Therefore, innovation surveys offer unique information that allows researchers to analyse innovation strategies and capacities to use, manage and search for external knowledge (Criscuolo *et al*., 2018).

The data set contains 5,511 observations of 2,782 firms. Of the observations, 40% represent firms with innovation activity in that period. Due to the UIS questionnaire only collecting KISs' use information for innovative firms, the final sample includes all the firms that declared that they had conducted at least 1 innovation activity in the period. Therefore, we work with an unbalanced panel data set of 2,205 observations from 1,466 firms (Table 1).

Table 1 about here

3.2 Dependent Variables

The UIS specifically asks whether the demand for technical skills (qualified employees in any particular area of knowledge) and social skills (abilities to cooperate and adaptability for teamwork skills) increased, stayed the same or decreased because of the innovation strategy developed (see Appendix, Table A1).

We consider the demand for qualifications as *technical skills*; while to capture *social skills* we build an indicator that includes both cooperation, communication and adaptation skills. Most of the firms in the sample maintained or increased their levels of demand for new skills in the recruitment process of new employees (Table 2). The percentage of firms that decreased their need for new recruitment was extremely low, and therefore they were not considered for the estimations.

Table 2 about here

3.3 Explanatory Variables

The study operationalized the concept of innovation openness, its key explanatory variable, through combinations of external KISs, defined as knowledge search strategies. Hence, the number and variety of the external KISs that a firm uses in the innovation process express the firm's degree of openness. The paper considers all the strategies that result from combinations of five sources of information: (1) suppliers, (2) customers, (3) competitors, (4) conferences, magazines and fairs and (5) universities and technological centres.[1] These sources have been used in other empirical studies (Laursen and Salter, 2006; Sofka and Grimpe, 2010; Backfisch, 2014; Criscuolo *et al*., 2018) and are comprehensive of a wide range of institutions and linkages that comprise the national innovation system.

The responses to the survey are converted from a four-point scale on the relevance of each knowledge and information source (where 1 is "high", 2 "medium", 3 "low" and 4 "irrelevant") into binary variables that take the value of 1 if the relevance of the source is low, medium and high and 0 if it is irrelevant. The variable *breadth* is constructed as combinations of all these sources. For *depth* strategies, following Laursen and Salter (2006), we combine the binary variables that take a value of 1 if the relevance of the source is high and 0 otherwise (see Table 3).

This means that, in the case of "low intensity", a search strategy called "suppliers" captures those firms that rate the use of suppliers as a source of innovation with low, medium or high importance (taking the value 1) and do not use any other sources to a low, medium or high extent. In the case of "high intensity", the same strategy

[1] For universities and research centers, the variable is created using two different sources: universities or research centers and consultants. Conferences, magazines and fairs, is constructed similarly. Reducing the number of sources facilitates the analysis of different combinations of sources. See appendix, Table A2.

captures those firms that rate the use of suppliers as a source of innovation with high importance (taking the value 1) and do not use any other sources to a great extent.

To analyse the effects of different openness strategies, combinations of the five different KISs produce 33 knowledge search strategies ranging from not using any external sources of information to using all 5 sources. The study maintains the criteria of *breadth* and *depth* to build the different strategies according to the intensity of the use of the sources (Table 3 displays the frequency of each strategy). At the end of the table, the openness strategies are ranked from 0 to 5 according to the use of sources. It can be observed that, for the "low intensity" scenario, the most frequent combination is all sources combined (41% of firms), while, in the "high intensity" scenario, it can be observed that the most frequent strategies are "no sources" (32.88%) or "one source" (31.75% of the firms).

Table 3 about here

3.3 Control variables

Table 4 presents a set of control variables used in the econometric models. Most of these variables refer to firms' characteristics, which have been widely tested as determinants of firms' innovation behaviour (Cohen, 2010). Moreover, to control for the presence of high-skilled human resources in the firms, the study includes a dummy that takes the value of one if the firm has at least one employee who has completed university education in its workforce. There is evidence for Uruguay that the presence of at least one professional in the firm positively affects the probability that the firm will engage in collaborative innovation activities (Bianchi *et al*., 2011).

Tables 4 about here

4. Results

Since the dependent variables contain two categories, the methodology used to estimate the impact of adopting open innovation strategies on the changes in recruitment needs is a multivariate logistic regression model. We run logit regression models for the pooled dataset, including fixed effects by sector and year. The estimation results can be observed in Tables 5 and 6. Table 5 reports the regression results of the *breadth* and *depth* indicators of innovation openness regarding the likelihood of increasing recruitment needs in technical skills and social skills. The first two columns show the baseline model estimation. Most of the control variables have the theoretically expected sign. Some variables, export share or being part of a group, are not statistically significant. It is important to note that the observed effect of these variables remains practically unchanged in all the estimates.

Specifically, it can be observed that the size of the firm is positively associated with an increase in the recruitment need for new employees with technical skills, while the demand for social skills is not significant. It is also apparent that firms companies that declared that they faced some limitations in undertaking innovation activities because they did not have skilled workers increased their recruitment needs for new employees with both technical and social skills. Finally, the use of internal sources as a source of information and knowledge for innovation required the recruitment of employees with more technical and social skills. In general, similar results have been observed in the literature on open innovation (Salter and Laursen, 2006; Criscuolo *et al*., 2018).

Table 5 about here

The estimations for the *breadth* and *depth* openness indicators are positive and statistically significant in explaining the likelihood of an increase in the recruitment needs for employees with higher technical skills and social skills (Table 5, columns 3 and 4). Thus, aligned with hypothesis 1, it can be observed that both human capital dimensions considered increase with the number of sources of information and knowledge (*breadth*) scanned by firms (technical skills: B=0.110, p<0.01; social skills: B=0.0757, p<0.10). Moreover, the estimations show that the intensity of the use of external sources (*depth*) increase the likelihood of increasing the recruitment of new employees with technical skills (B=0.182, p<0.01) and social skills (B=0.137, p<0.01), confirming the hypothesis 2. Table 6 reports the results of the logistic regression on the likelihood of increasing the recruitment needs of technical and social skills regarding the adoption of different open innovation strategies (combinations of KISs), distinguished by the level of intensity in the use of sources. This allows us to approach hypotheses 1 and 2 from a different perspective. A quick view of the estimation allows the extraction of three main results that reinforce the findings of *breadth* and *depth* (Table 5). First, the number of open innovation strategies that demand new employees with higher technical skills is larger than the number affecting the new recruitment of employees with higher social skills (Table 6). Second, the number of combinations that are positively associated with the likelihood of increasing the recruitment needs for people with more technical and social skills is greater when the intensity of use of external sources for innovation is high than when this intensity is low (Table 6, comparing columns 1 with 3 and 2 with 4). Third, to the extent that combinations involve a greater number of actors, the demand for new skills also increases, mostly when the intensity of the use of sources is high.

With regard to technical skills, it can be observed that the number of openness strategies that significantly affect the likelihood of new recruitment increases with the

number of sources implied. For instance, when considering low intensity of the use of sources (column 1), no strategies, including only one source, increase the recruitment needs compared with companies that are not involved in open innovation. Similarly, only two strategies, including two sources, increase the recruitment needs of more technically qualified employees (universities and customers: B=0.780, p<0.10; universities and competitors: B=1.659, P<0.10). In addition, it can be observed that the rest of the strategies involving more actors (three, four or all sources) are more likely to demand new employees with high technical skills. These combinations of sources usually include both close and distant actors.

Table 6 about here

Hypothesis 2 stated the likelihood that the recruitment need for both technical and social skills is more likely to increase with the intensity of use of different KISs in open innovation strategies. The estimation results in Table 6 show that some openness strategies are more likely to demand new technical and social skills when increasing the intensity in the use of different sources. This effect is observed in the case of both strategies involving small and large numbers of sources. In the case of technical skills, it can be observed that firms that only use universities and research centres ("universities") intensively as KIS demand new technical skills (B=0.519, p<0.01), while, for social skills, the same strategy is not significant. It is remarkable that, considering high intensity use of KIS, all strategies that demand the recruitment of new technical skills involve the participation of universities. In addition, some combinations involving two sources other than universities, also increase the need for new technical skills when increasing the intensity of the use of the sources (suppliers and customers: B=0.382, p<0.10; suppliers and fairs: B=0.730, p<0.05; customers and fairs: B=0.543, p<0.10).

In the case of social skills, an increase in the recruitment needs is observed in strategies integrating two and three sources. It can also be stated that this effect is observed in strategies involving cognitively close and distant sources (e.g. suppliers and customers: B=0.590, p<0.05; universities and customers: B=0.990; p<0.01; suppliers, universities and customers: B=0.790, p<0.05; suppliers, competitors and fairs: B=1.425, p<0.05). In addition, when comparing low versus high intensity use of sources, social skills are more likely to be demanded when strategies involve four sources of information and knowledge. Table 7 shows that the likelihood of increasing the recruitment of new employees with higher social skills is around 20–30% compared with firms that are not involved in open innovation when the sources are used intensively. However, we do not have a theoretical explanation for the negative sign of the strategy: "Universities only" (Table 6, column 2).

Finally, hypothesis 3 stated that technical skills are likely to be demanded for low-intensity and high-intensity use of sources while social skills are likely to be demanded only for highly intensive use of sources. The estimation results show that technical skills are more likely to be demanded than social skills in both scenarios considered. It can be observed that some strategies including two or three sources increasingly demand technical skills in the scenario of the narrow use of sources, while, in this context, any strategy increases the demand for social skills. However, in the scenario of deep use of sources, both technical and social skills are demanded. The marginal effects of statistically significant combinations are summarized in Table 7. It can be observed that the strategy combining two distant actors (universities and competitors) increases the likelihood of recruiting new employees with higher technical skills by 40.9%. The combinations that increase the likelihood of recruitment of new employees with higher

technical and social skills to a greater extent include a high number of sources or in some cases a small number of distant sources.

Table 7 about here

It can be observed that the intensity of use is a determinant compared with the number of KISs to explain the differences between technical and social skills. For instance, any strategy of open innovation is statistically significant in explaining an increase in the likelihood of recruiting people with higher social skills when the use of sources is narrow (Table 6, column 2), with the exception of the negative sign of the strategy "universities only". Moreover, when the intensity of the use of sources is high (Table 6, columns 3 and 4), it can be observed that the number of statistically significant combinations increases for both technical and social skills. In sum, aligned with Noteboom (2007), social skills as well as technical skills are important to integrate cognitively distant sources of knowledge and to combine near and distant sources. Thus, hypothesis 3 can be confirmed.

Overall, the estimations confirm that integrative strategies increase the demand for both technical and social skills. Looking for the individual effects of different combinations of sources, the study investigated whether the intensity of the use of different sources in openness strategies moderates the need for new employees to be recruited. When openness strategies include narrow intensity in the use of sources, it can be observed that only technical skills are demanded; however, when considering firms that only use different sources intensively, it is apparent that both technical and social skills are demanded.

We test the robustness of the estimates obtained through logit models. The coefficients are similar when estimated using probit or ordinary least squares (OLS)

models. We also estimate two different tobit models, one left-censored and the other right-censored, to obtain greater accuracy regarding specific recruitment patterns. The coefficients are similar to those obtained using ordered logit models or OLS.

Moreover, in order to control potential endogeneity bias, we use a reduced panel dataset that include only those firms that have been surveyed at least two times (1,282 observations from 543 firms). Hence, we instrumented the independent variables (*breadth* and *depth*) using their measures one in lagged period ($breadth_{t-1}$ and $depht_{t-1}$). The estimates from IVProbit models resulted mostly in no significe and the Wald test of the exogeneity of the instrumented variables was not significant. Therefore, we do not observe endogeneity bias, and the original logit binomial model offers the most consistent estimates.

5 Discussion and Conclusions

The benefits of innovation openness have been widely discussed in the literature on the management and economics of innovation. Researchers have shown the benefits of combining different openness strategies; complex and balanced combinations of knowledge sources provide opportunities for enhanced innovation performance in terms of product and process innovation (Backfisch, 2014; Criscuolo *et al*., 2018). This study deals with the effects of innovation openness, specifically analysing the changes in the recruitment of people associated with new demands for technical skills and social skills. In doing so, the paper contributes to the knowledge on the human aspect of innovation, often little considered in the literature on open innovation (Bogers *et al*., 2018).

Using several theories and the most recent empirical evidence in this field, the study tried to improve the understanding of the consequences of open innovation, focusing on the effects that adopting different openness strategies have on the need to

recruit people with higher technical and social skills. The estimations show that the adoption of broad open innovation strategies demands employees with more technical and social skills. However, it was observed that technical skills are more likely to be demanded than social skills when firms establish intensive searching strategies with different actors in relation to those firms that do not implement open strategies. Finally, the study looked for the effects on recruitment needs of specific strategies, from simple strategies including only one source to more integrative strategies including both close and distant sources. It found that technical skills are demanded in a large number of combinations (integrative) compared with social skills, which are more likely to be required only when the intensity in the use of sources is high.

For technical skills, it is important to point out that, although the number of strategies is statistically significantly greater when the intensity of the use of the sources is also greater, it was observed that the more frequent combinations include only a small number of actors (two sources). This would indicate that companies focusing intensively on the use of sources are not able (technically) to incorporate a greater number of sources. Regarding social skills, open strategies that are more likely to demand new employees with higher social abilities combine more sources. Thus, the effect of increasing the intensity of the use of sources and the number of sources combined is rather more important for social skills than for technical skills.

In sum, comparing technical and social skills, the study confirms that technical skills are more likely to be demanded than social skills according to different search strategies (combinations of sources), from narrow to deep search combinations. Some "simple combinations" integrating one or two sources appear to be associated with new recruitment needs for technical skills and social skills. However, in accordance with the literature, these simple strategies do not allow firms to achieve higher innovation

performance (Villena *et al*., 2011; Criscuolo *et al*., 2018) and make firms face the challenge of recruiting highly qualified employees (Petroni *et al*., 2012).

The results of this study have implications for the academia, policy makers and practitioners, and for employees.

Regarding the academia, the results are consistent with the expectations from the literature reviewed but create some controversy related to the origins of the adoption of open innovation strategies. According to Chesbrough (2006), many firms adopt open strategies for innovation as a response to insufficient suitable internal resources to adopt a close strategy or even because of the inability to recruit knowledgeable people associated with financial limitations, small size of firms or low business attractiveness. However, the study demonstrates that achieving high innovation performance by capturing new ideas, valuable information and knowledge from different sources is associated with new recruitment of people with high technical and social skills. Overall, the paper demonstrates that firms that increasingly adopt openness for innovation and engage with external sources face the need to recruit employees with the ability to understand and absorb knowledge in collaborative environments. This confirms that open innovation processes occur in a very dynamic way, challenging the company to be able to absorb information and knowledge for both outside-in and inside-out flows. The literature has shown that this requires the internal development of capabilities to absorb and exploit new knowledge. However, our study demonstrates that this process must be complemented with the incorporation of new workers with higher technical and social skills, which are necessary to implement various strategies, mainly those that integrate a large number of KISs.

Another implication for academia is associated with the specific difficulties of training and transferring soft skills (intrapersonal and interpersonal) rather than hard skills

(technical). This lack of soft-skill transfer results in an extremely costly waste of time, energy and money for firms (Laker and Powell, 2011), and therefore, academia should improve soft-skill training in higher education and in more elementary courses (Ngang *et al*., 2015).

For practitioners, this study demonstrates that adopting and maintaining open innovation strategies is a challenge for firms, since it requires new technical and social skills, to intensify open innovation strategies and advance in implementing more open and integrative strategies. Hence, while enhanced innovation performance has been associated with the adoption of complex and integrative combinations of sources, achieving high performance will demand employees with higher technical and social skills. This study highlights the need to attract and retain staff with high qualifications and abilities to adapt and work in groups, which is especially challenging in less developed contexts. In this sense, implementing human resource practices such as team rewards or extensive selection have been demonstrated to be useful to identify, attract and retain high-skilled workers (Laursen and Foss, 2014). In addition, improving the knowledge base allows firms to intensify their collaborations in networks, which may increase specific knowledge and amplify the possibilities to contact and recruit new employees (Podmetina *et al*., 2013).

For policy-makers, the main contribution of this study is that when considering policies promoting open innovation activities, they must also consider that firms should be able to improve their human capital as a response to an incremental process of open innovation, which usually integrates close and distant sources of information and knowledge. Therefore, open innovation actions should be complemented with a recruitment policy, which, in the case of SMEs, should include public subsidies for hiring and training highly qualified workers. The study shows that technical skills (in any area

of knowledge) are usually demanded more, regardless of the intensity of the use of sources for openness strategies. Technical skills are easily observable. However, social skills that appear to be demanded in more integrative strategies with a high use of sources are more difficult to identify but easier to train (Petroni *et al*., 2012).

In addition, our study contributes to the open debate on job destruction and technology change (e.g. Frey and Osborne, 2017; Aghion *et al*., 2019). In Uruguay, as in many countries facing the current ICT diffusion wave based on robotics and automation, policy-makers, unions and firms have been discussing the potential impact of the technical change and innovation in employment, productivity and business models. In the specific case of Uruguay, this issue is of critical concern among the "mega trends" identified by the Uruguayan National Development Strategy (OPP, 2019), as a critical challenge for the country. This paper offers relevant implications to inform this discussion beyond the alternatives to mitigate an apparent inevitable job destruction process by offering evidence of potential job creation related to innovation activities and innovation strategies beyond the incorporation of ICT. In addition, while recruiting highly skilled workers is a challenge for firms, it can also be an opportunity to attract and retain high-skilled people to work on broad and integrative innovation projects, increasing the firms' human capital and supporting their competitive advantage (Laursen and Salter, 2014).

For employees, the study highlights the importance of social skills and competencies (such as working groups or communication) to manage open innovation strategies. They should be trained in these aspects and incorporate them into the technical skills needed to work in innovation contexts. These traits will be valued and desired more by firms.

The paper presents a number of limitations. First, the results of this study must be read within the context of a developing country. Uruguay is a developing country with a

challenging shortage of qualified human resources (Bello-Pintado and Barcés-Galdeano, 2017). In this sense, firms have typically faced such constraints, which can limit the internal development of capabilities associated with the innovation process. Furthermore, it may be desirable to complement the debate on the human capital consequences of open innovation by considering in the future the impact of internal training practices as determinant for the absorptive capacity of firms. Recent studies suggest that training affects performance, through the effect on developing exploitation capabilities for innovation (Hernández-Perlines *et al*., 2015). Second, this study only considers search strategies rather than search and collaboration strategies. Further research should address a broader measurement of the degree of openness that considers the external knowledge sources and the linkages with other agents as well as formal collaboration agreements in which firms are engaged to innovate. In addition, data available should allow to identify between inside-out and outside-in flows in order to identify the consequences and determinants of each strategy (Michelino *et al*., 2014). Moreover, it is necessary to integrate the study of complementarities (Belderbos *et al*., 2006) – both between different external sources and between internal and external sources – and the concept of strategies as knowledge source combinations (Backfisch, 2014). This may contribute to improving the understanding of the specific combinations of sources, which depend on the internal and the external context of the firm (Lazzarotti *et al*., 2015). Finally, the econometric strategy is based on the estimation of correlations; hence, the results have no causal claims. Due to low number of waves of the UIS that contain information about the recruitment of skills, the use of fixed-effect models or other estimate methods to control endogeneity bias are still not available.

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Table 1. Structure of the panel

UIS Wave					
2006	**2009**	**2012**	**N**	**%**	**% Cum.**
X	X	X	196	13.37	13.37
	X	X	183	12.48	25.85
X	X		114	7.78	33.63
X		X	50	3.41	37.04
		X	216	14.73	51.77
	X		324	22.10	73.87
X			383	26.13	100

Table 2. Dependent Variables: descriptive statistics

	Technical Skills		**Social Skills**			
	Qualifications		**Cooperation and communication**		**Adaptation**	
Increased	986	44.72	806	36.55	758	34.58
Constant	1,156	52.43	1,353	61.36	1,404	63.67
Decreased	62	2.81	46	2.09	43	1.95
Total	2,204	100	2,205	100	2,205	100

Table 3 – Frequency of Openness Strategies

	Low Intensity		High Intensity	
Combinations	N	%	N	%
No external sources	82	3.72	725	32.88
Suppliers only	36	1.63	95	4.31
Universities only	42	1.90	179	8.12
Customers only	25	1.13	228	10.34
Competitors only	11	0.50	41	1.86
Fairs only	27	1.22	157	7.12
Suppliers and universities	24	1.09	34	1.54
Suppliers and customers	45	2.04	90	4.08
Suppliers and competitors	5	0.23	9	0.41
Suppliers and fairs	34	1.54	38	1.72
Universities and customers	28	1.27	69	3.13
Universities and competitors	6	0.27	11	0.50
Universities and fairs	44	2.00	85	3.85
Customers and competitors	14	0.63	58	2.63
Customers and fairs	33	1.50	51	2.31
Competitors and fairs	11	0.50	7	0.32
Suppliers, universities and customers	54	2.45	32	1.45
Suppliers, universities and competitors	4	0.18	2	0.09
Suppliers, universities and fairs	64	2.90	21	0.95
Suppliers, customers and competitors	53	2.40	40	1.81
Suppliers, customers and fairs	56	2.54	25	1.13
Suppliers, competitors and fairs	9	0.41	7	0.32
Universities, customers and competitors	25	1.13	15	0.68
Universities, customers and fairs	41	1.86	37	1.68
Universities, competitors and fairs	19	0.86	8	0.36
Customers, competitors and fairs	24	1.09	21	0.95
Suppliers, universities, customers and competitors	76	3.45	14	0.63
Suppliers, universities, customers and fairs	193	8.75	24	1.09
Suppliers, universities, competitors and fairs	28	1.27	5	0.23
Suppliers, customers, competitors and fairs	103	4.67	21	0.95
Universities, customers, competitors and fairs	87	3.95	30	1.36
All sources	902	40.91	26	1.18
No sources	82	3,72	725	32,88
One source	141	6,39	700	31,75
Two sources	244	11,07	452	20,50
Three sources	349	15,83	208	9,43
Four sources	487	22,09	94	4,26
All sources	902	40,91	26	1,18

Table 4 – Control Variables. Descriptive Statistics

		Total Sample	
	Variable	Mean	Std Err.
(1)	% Export	15.71	30.11
(2)	Firm size (ln)	4.19	1.36
(3)	Age (ln)	2.94	0.93
(4)	Foreign direct investment (D)	0.17	0.38
(5)	Part of a group (D)	0.22	0.41
(6)	Financial obstacles (D)	0.37	0.48
(7)	Shortage of qualified personnel (D)	0.49	0.49
(8)	Government support (D)	0.12	0.33
(9)	Human capital stock (ST professionals/employees)	12.19	15.86
(10)	Manufacturing industry (D)	0.50	0.50
(11)	Uses internal sources (D)	0.92	0.29

(1) Variable that indicates the percentage of firm's total sales corresponding to export; (2) number of employees of the firm (ln); (3) difference between the date when the firm initiated its activities and the year of the survey (logs); (4) dummy variable that indicates whether the firm declares a positive percentage of foreign capital; (5) dummy variable that indicates whether the firm belongs to an economic group; (6) dummy variable that indicates whether the firm experienced financial obstacles to innovation; (7) dummy variable that indicates whether the firm experienced obstacles to innovation because of shortages of qualified personnel; (8) dummy variable that indicates whether the firm received any public funding; (9) professionals/employees; (10) dummy variable that indicates whether the firm belongs to the manufacturing sector; and (11) dummy variable that indicates whether the firm declared that it used internal sources of information.
Source: Developed by the authors based on the UIS database.

Table 5. Openness Breadth and Depth. Binomial Logit. Dependent Variable: Increasing Recruitment Needs

	Baseline		Breadth and Depth	
	Technical skills (1)	Social skills (2)	Technical skills (3)	Social skills (4)
% Export	-0.00111	-0.00255	-0.00153	-0.00280
	(30.11)	(30.10)	(30.11)	(30.10)
Size (ln)	0.126***	-0.000241	0.127***	-0.00172
	(1.362)	(1.362)	(1.362)	(1.362)
Age (ln)	0.00947	-0.107*	0.0147	-0.104*
	(0.936)	(0.936)	(0.936)	(0.936)
Foreign direct investment (D)	0.235*	0.245*	0.242*	0.247*
	(0.377)	(0.377)	(0.377)	(0.377)
Part of a group (D)	0.00866	0.215	0.00873	0.217*
	(0.413)	(0.412)	(0.413)	(0.412)
Financial obstacles (D)	-0.153	-0.0823	-0.208**	-0.123
	(0.483)	(0.483)	(0.483)	(0.483)
Shortage of qualified personnel (D)	0.390***	0.399***	0.307***	0.334***
	(0.500)	(0.500)	(0.500)	(0.500)
Government support (D)	0.242*	0.0614	0.191	0.0196
	(0.330)	(0.330)	(0.330)	(0.330)
Human capital stock (ST professionals/employees)	0.00516*	-0.000484	0.00464	-0.000874
	(15.89)	(15.90)	(15.89)	(15.90)
Manufacturing industry (D)	-0.234**	-0.410***	-0.234**	-0.407***
	(0.500)	(0.500)	(0.500)	(0.500)
Uses internal sources (D)	0.591***	0.517**	0.357*	0.348
	(0.268)	(0.268)	(0.268)	(0.268)
Year=2009	-0.193*	-0.0946	-0.176*	-0.0797
	(0.484)	(0.484)	(0.484)	(0.484)
Year=2012	-0.617***	-0.341***	-0.596***	-0.319**
	(0.456)	(0.456)	(0.456)	(0.456)
Depth			0.182***	0.137***
			(1.195)	(1.195)
Breadth			0.110***	0.0757*
			(1.438)	(1.438)
Constant	-1.202***	-1.037***	-1.575***	-1.298***
Log pseudolikelihood	-1455.3653	-1254.6249	-1432.3864	-1244.3889
Observations	2,190	2,191	2,190	2,191

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

Table 6. Openness Strategies. Dependent Variable: Increasing Recruitment Needs

	Low Intensity		High Intensity	
	Technical skills	Social skills	Technical skills	Social skills
	(1)	(2)	(3)	(4)
Export %	-0.00150	-0.00299	-0.00145	-0.00280
Log firm size	0.119***	-0.00316	0.113***	-0.00647
Age	-0.00281	-0.128**	0.0247	-0.105*
Foreign direct investment (D)	0.207	0.250*	0.250*	0.268*
Part of a group (D)	0.00620	0.211	0.0446	0.253*
Financial obstacles (D)	-0.194**	-0.131	-0.214**	-0.108
Shortage of qualified personnel (D)	0.355***	0.380***	0.358***	0.374***
Government support (D)	0.200	0.0278	0.183	0.0312
Human capital stock	0.00333	-0.000802	0.00374	-0.00122
Manufacturing industry (D)	-0.227**	-0.404***	-0.251**	-0.425***
Uses internal sources (D)	0.340*	0.393*	0.499***	0.420**
Year=2009	-0.175	-0.109	-0.161	-0.0516
Year=2012	-0.577***	-0.335**	-0.600***	-0.304**
Suppliers only	-0.251	-0.00112	0.110	0.299
	(0.474)	(0.484)	(0.228)	(0.251)
Universities only	0.577	-1.016*	0.519***	0.0645
	(0.421)	(0.614)	(0.171)	(0.199)
Customers only	0.207	-0.981	0.0869	0.0235
	(0.500)	(0.673)	(0.161)	(0.176)
Competitors only	0.0228	-1.105	-0.179	0.129
	(0.673)	(1.082)	(0.357)	(0.377)
Fairs only	-0.107	-0.0309	0.176	0.231
	(0.537)	(0.566)	(0.186)	(0.205)
Suppliers and universities	0.340	0.505	0.613*	0.554
	(0.536)	(0.537)	(0.372)	(0.376)
Suppliers and customers	0.0502	-0.663	0.382*	0.590**
	(0.452)	(0.529)	(0.228)	(0.244)
Suppliers and competitors	0.256	-	-0.0510	0.551
	(0.902)		(0.780)	(0.726)
Suppliers and fairs	0.137	0.0957	0.730**	0.445
	(0.477)	(0.511)	(0.339)	(0.367)
Universities and customers	0.780*	0.533	1.115***	0.990***
	(0.458)	(0.483)	(0.267)	(0.269)
Universities and competitors	1.659*	-	0.909	0.937
	(0.890)		(0.656)	(0.683)
Universities and fairs	0.574	-0.236	0.520**	0.211
	(0.407)	(0.481)	(0.245)	(0.275)
Customers and competitors	0.760	0.582	0.174	-0.230
	(0.573)	(0.667)	(0.275)	(0.359)
Customers and fairs	0.103	-0.515	0.543*	0.00335
	(0.463)	(0.576)	(0.306)	(0.361)
Competitors and fairs	-0.0693	-0.389	0.488	-0.316
	(0.756)	(0.842)	(0.809)	(1.101)
Suppliers, universities and customers	0.799**	0.431	0.812**	0.790**
	(0.389)	(0.415)	(0.370)	(0.392)
Suppliers, universities and competitors	-0.130	-	0.292	-
	(1.280)		(1.314)	
Suppliers, universities and fairs	0.790**	0.225	0.653	0.0472
	(0.375)	(0.412)	(0.457)	(0.532)
Suppliers, customers and competitors	0.681*	0.308	0.363	-0.110
	(0.381)	(0.425)	(0.335)	(0.367)
Suppliers, customers and fairs	-0.0737	0.547	0.131	0.388
	(0.402)	(0.397)	(0.428)	(0.433)
Suppliers, competitors and fairs	-0.789	0.200	0.779	1.425**
	(1.089)	(0.842)	(0.700)	(0.680)
Universities, customers and competitors	0.425	0.272	0.190	0.395
	(0.489)	(0.521)	(0.562)	(0.625)
Universities, customers and fairs	0.548	0.0475	0.768**	0.775**
	(0.423)	(0.462)	(0.357)	(0.354)
Universities, competitors and fairs	1.219**	-0.0890	0.419	1.230*
	(0.533)	(0.641)	(0.748)	(0.736)
Customers, competitors and fairs	0.484	0.555	0.420	0.514
	(0.534)	(0.525)	(0.440)	(0.438)
Suppliers, universities, customers and competitors	0.184	-0.354	1.696***	0.792
	(0.360)	(0.403)	(0.637)	(0.538)
Suppliers, universities, customers and fairs	0.984***	0.0839	1.375***	0.976**
	(0.307)	(0.334)	(0.462)	(0.423)
Suppliers, universities, competitors and fairs	0.0205	-0.427	0.990	0.874
	(0.497)	(0.562)	(0.921)	(1.015)
Suppliers, customers, competitors and fairs	0.602*	-0.149	-0.0323	-0.135
	(0.333)	(0.370)	(0.439)	(0.563)
Universities, customers, competitors and fairs	1.122***	0.202	1.465***	0.984**
	(0.344)	(0.371)	(0.406)	(0.385)
All sources	0.857***	0.337	0.964**	0.301
	(0.276)	(0.297)	(0.436)	(0.443)
Constant	-1.516***	-0.955**	-1.347***	-1.138***
Log pseudolikelihood	-1424.647	-1229.519	-1422.298	-1229.380
Observations	2,190	2,176	2,190	2,189

Table 7. Openness Strategies. Marginal Effects

Openness strategies Low Intensity	
	Technical skills
Universities and customers	0.192*
Universities and competitors	0.409*
Suppliers, universities and customers	0.197**
Suppliers, universities and fairs	0.195**
Suppliers, customers and competitors	0.168*
Universities, competitors and fairs	0.301**
Suppliers, universities, customers and fairs	0.243***
Suppliers, customers, competitors and fairs	0.149*
Universities, customers, competitors and fairs	0.277***
All sources	0.211***
	Social Skills
Universities only (-)	-0.198*
Openness strategies High Intensity	
	Technical skills
Universities only	0.128***
Suppliers and universities	0.151*
Suppliers and customers	0.0945*
Suppliers and fairs	0.180**
Universities and customers	0.275***
Universities and fairs	0.128**
Customers and fairs	0.134*
Suppliers, universities and customers	0.201**
Universities, customers and fairs	0.190**
Suppliers, universities, customers and competitors	0.419***
Suppliers, universities, customers and fairs	0.340***
Universities, customers, competitors and fairs	0.362***
All sources	0.238**
	Social Skills
Suppliers and customers	0.115**
Universities and customers	0.192***
Suppliers, universities and customers	0.154**
Suppliers, competitors and fairs	0.277**
Universities, customers and fairs	0.151**
Universities, competitors and fairs	0.239*
Suppliers, universities, customers and fairs	0.190**
Universities, customers, competitors and fairs	0.191**