JOURNAL OF TECHNOLOGY MANAGEMENT & INNOVATION

JOTMI

VOLUME 12 - ISSUE 3 (2017)

WWW.JOTMI.ORG

Universidad Alberto Hurtado - Facultad de Economía y Negocios

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ISSN: 0718-2724. (http://jotmi.org)

University industry links and product innovation: cooperate or contract?

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Abstract: The role of universities in product innovation has received considerable attention over the past decade. However, little is known about how the type of formal university-firm interaction predicts innovative performance and the degree of novelty of new products. This research differentiates two forms of firm high-relational interaction with universities: R&D contracting and cooperation. We exploit the panel structure of a dataset of 5,858 Spanish manufacturing firms with fixed-effects models. The empirical analysis finds that, although both contracting and cooperation predict product innovative performance, the two activities differ in the degree of novelty of new product outcomes. The implications are that the codified nature and asymmetric scope of R&D contracting is more suitable for exploitative innovation, resulting in product innovation that is incremental in nature. On the other hand, the possibility to exchange and create tacit knowledge and the explorative nature of R&D cooperation provide firms with the opportunity to better access the broad knowledge base of universities, leading to product innovations with a higher degree of novelty.

Keywords: R&D cooperation; R&D contracting; innovation; universities; product novelty.

Submitted: January 26th 2017 / Approved: August 8th 2017

Introduction

The academic literature consistently emphasizes that firms rarely innovate alone and that the development of new products increasingly depends on the firm's capacity to access and exploit external sources of technological knowledge (Laursen and Salter, 2006). Thus innovation is recognized as a distributed and interactive process among a number of economic actors rather that the province of individual firms (West et al., 2014).

Among the wide variety of agents with which firms can relate, universities have taken pride of place as partners, and academic research has come to be considered as one of the engines of industrial innovation (Perkman et al., 2013). Based on this belief, many OECD governments have launched, starting from the late 1970s, important initiatives to encourage greater interaction between universities and firms. However, despite this interest, tracing the effects of universities on industrial innovation has been a difficult task because of the wide spectrum of mechanisms through which knowledge may be exchanged as well as the complex set of factors that moderate the relationships between these agents (Ahrweiler, Pyka and Gilbert, 2011). University-industry links may involve a number of different organizational arrangements, ranging from collaborative research to temporary personnel exchanges. In this sense, our knowledge on the role of universities in industrial innovation is still limited since much of the existing research focuses on low-relational activities, such as patenting and licensing, while largely neglecting the linkages that are more intensive and used by firms more often, such as joint research and contract research (D'Este and Patel, 2007). This is especially true when it comes to the characteristics of the firm strategy for exploiting university knowledge and the use of systematic, large-scale empirical data to analyze it. As a result, multiple and even contradictory messages emerge from the empirical works carried out so far. Thus, while some studies show that university-industry links positively affect firms' innovative performance (Aschhoff and Schmidt, 2008; Bellucci and Pennacchio, 2016), others reveal an insignificant or even negative relationship (Miotti and Sachwald, 2003; Tsai and Wang, 2009).

In this paper, we argue that in order to disentangle the role of universities in industrial innovation, it is important to pay more attention to the specific characteristics of the interaction channel. In particular, we focus on two alternative formal arrangements with universities: R&D contracting and cooperation. According to Perkmann and Walsh (2007), these two types of links imply a higher level of relational involvement between universities and firms compared to other mechanisms such as mobility (e.g. academic entrepreneurship, human resource transfer) and transfer links (e.g. licensing of university-generated IP). Therefore, they may provide a better understanding of the interactive nature of innovation processes. As these authors point out, "in the context of open innovation, it is particularly the links with high relational involvement that are of interest, as they facilitate the building and maintenance of interorganizational relationships" (Perkmann and Walsh, 2007: 563).

The present study addresses the following questions: (1) Are (both types of) high-relational research interactions with universities (R&D contracting and cooperation) significant predictors of firm innovative performance? (2) If so, how do R&D contracting and cooperation with universities differ in terms of the novelty of product innovation and knowledge generated? In so doing this study makes several contributions to the literature.

First, while previous studies have focused on the impact of cooperation with universities on different measures of innovative performance, no detailed empirical evidence exists on the role of contract

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ISSN: 0718-2724. (http://jotmi.org)

research; we have not found any study that simultaneously considers the effects of these two types of university-industry relationship on firm innovative performance. This is surprising given that the differences between collaboration, as a hybrid form of boundary-spanning organization, and external contracting to the market are stressed in the management literature (Lucena, 2011). This study builds on a clear distinction between cooperation and contracting and thus sheds light on the process through which universities may influence innovation.

Second, this work is not only among the first to compare the effect of university-industry links derived from two types of relationships, but it also carries out the analysis using panel data. Many of the empirical studies on university-industry relationships have drawn mainly from survey data, especially those coming from the Community Innovation Surveys (CIS). The use of this kind of data has allowed researchers to consider large samples of firms belonging to different industrial sectors, thus gaining a broad view of the phenomenon. However, most of these studies have a drawback in that they are cross-sectional and employ a controlling-on-observables estimation approach, which makes it difficult to account for certain sources of endogeneity (Lucena, 2011).

This article is organized in the following way. First, we discuss the potential effects of R&D contracting and cooperation with universities on firm innovative performance. We then move to a description of our research design followed by the presentation of the empirical results. We conclude by discussing the implications of our findings and possible future research lines.

Literature Review

R&D Contracting and University-Industry Cooperation as Innovation Strategies

Schartinger et al. (2002 identify sixteen types of 'channels' or 'mechanisms' through which knowledge may be transferred between academics and industry personnel, grouped into four categories: joint research, contract research, mobility, and training. Using this classification as a starting point, Perkmann and Walsh (2007) suggest a more general typology by distinguishing university-industry relationships from other mechanisms such as human mobility or technology transfer. According to these authors, while the former imply links with a high-relational involvement where university researchers and industry employees work together on a specific project, the latter are more generic as they do not necessarily require face-to-face contact between academics and industry users.

The higher-involvement relationships are precisely the focus of this paper: R&D contracting and R&D cooperation. Although there is some debate in the literature on the existence of a sharp distinction between these two types of relationships, the organizational literature on the boundaries of the firm has stressed several differences between cooperation and contracting as innovation governance modes, which are equally applicable in the context of university-industry links. From a transaction cost perspective, contracting represents a governance mode close to market structure, in which the firm opts to farm out to universities, entirely or partially, the development of an R&D project. In this kind of arrangement firms specify unilaterally what type of expertise they require (specific objectives and deliverables), and the academic researchers perform the assignment against payment (Perkmann and Walsh, 2007). In contrast, cooperation represents a hybrid governance mode between hierarchical transactions within firms and arms-length transactions in the market place. In collaborative arrangements both parties participate in the activities and contribute to the relationship by sharing knowledge and pooling resources.

Due to these differences in the organization of the relationship, contracting and cooperation vary not only in terms of the firm's control and ownership of outcomes, but also in their capacity to ease the exchange of knowledge and/or resources between academics and industry employees. Therefore, it is reasonable to assume that the effect of university-industry relationships on industrial innovation is likely to differ across the type of agreement adopted for organizing the relationship.

Related to R&D contracting, the literature has documented a number of expected benefits. In general, it has been suggested that this strategy allows a firm to tap into knowledge and resources from external partners as well as to focus more on its internal core capabilities, thereby facilitating faster product development (Tsai and Wang, 2009). In the specific case in which the provider of R&D services is a university, the benefits of R&D outsourcing may be even higher since universities may provide different and complementary skills and resources with a large potential for learning (Un et al., 2010) .

Bearing in mind the above-mentioned aspects and the fact that in R&D contracting the activities are explicitly commissioned by the firm, it is reasonable to expect a positive effect of this strategy on a firm's innovative performance. However, R&D outsourcing to universities may encounter some particular problems that may limit its success as innovation strategy. On the one hand, contracting may lead the firm to lose the capacity to develop the R&D activities internally, thus weakening its technological competences. In addition, contracting may imply some extent of knowledge leakage from the firm, which in turn may compromise the distinctiveness of the innovative outcome. Further, problems of culture clashes and bureaucratic inflexibility may hinder the transfer of knowledge from universities to industrial firms (Knudsen, 2007). In these situations, more integrative strategies are required in order to facilitate the assimilation and exploitation of university knowledge. Cooperation, therefore, appears as an important technology acquisition alternative. By cooperating with universities, firms may not only share the risks and costs associated with basic research, but also build capabilities they would not get by simply contracting out the work to meet their needs. Because of the close interaction during a collaborative agreement, not only the knowledge itself, but also the competencies of the partners can be shared (Bodas-Freitas and Verspagen, 2017; Fey and Birkinshaw, 2005). In this way, cooperation may be a more appropriate strategy to exploit a pool of different but complementary knowledge.

Nevertheless, despite the potential benefits of cooperation with universities, this strategy may also suffer some limitations. In collaborative arrangements the objectives and outcomes are jointly defined by the partners and, taking into account the generation of output of high academic relevance primarily motivates university involvement, cooperation might be targeted at more basic research and be long-term oriented. In fact, there is a general belief that research partnerships between universities and firms are usually aimed at the development of basic research with no clear commercial application (Un et al., 2010). Thus, cooperation with universities may not directly influence the success of a firm's innovation output; rather, it may just be oriented to foster learning processes and capacity-building.

The empirical evidence on the effect of these two types of university-industry relationships is also not conclusive. In the case of R&D outsourcing, while a number of studies point to its benefits on firms' innovative performance, systematic empirical studies on its effectiveness remain scarce (Stanko and Calantone, 2011). Three exceptions are the papers by Tsai and Wang (2009), Vega et al. (2009a), and Fey and Birkinshaw (2005), which explore the effect R&D outsourcing on technological innovative performance. In these studies R&D outsourcing is found to have no significant effect on technological innovation, although none of them distinguishes the outsourcing of R&D services to universities from the R&D outsourcing to other agents.

Regarding cooperation, the empirical literature is more extensive but has produced contradictory results. Based on data for a large sample of Dutch innovating firms, Belderbos et al. (2004) find that firms that cooperate with universities in their R&D activities show higher sales growth due to new products than firms that do not cooperate. However, there are studies that also use data from innovation surveys and come up with different conclusions. Miotti and Sachwald (2003), for instance, find that cooperation with public institutions has no significant effect on the share of turnover from innovative products.

In sum, we can find different arguments to support opposite expectations about the success of R&D contracting and cooperation with universities as innovation strategies. On the one hand, R&D outsourcing has the potential to promote a faster innovation process, but due to the barriers arising from the cultural and organizational differences between firms and universities, several coordination and communication problems may emerge from this strategy thus limiting its impact on innovative performance. On the other hand, although cooperation may enable the firm to face coordination problems more effectively than technology acquisition via market procurement, the basic or fundamental nature of the research activities characterizing this kind of arrangement may make difficult to obtain tangible outcomes, especially in the short term.

The Novelty of the Innovation Outcome

So far we have discussed the effects of university-industry relationships taking into account the organizational form adopted for managing the relationship. However, the search for innovation can span not only organizational boundaries but also technological ones, leading to another dimension in the analysis: the degree of novelty of the innovation outcome (Kobarg, et al., 2017; D'Este et al., 2016). Along these lines, the literature review suggests that the benefits of university-industry relationships could be investigated by considering the explorative nature of interaction and the degree of novelty of innovative result (Bellucci and Pennacchio, 2016). Following March's (1991) dichotomy of exploration and exploitation, several researchers have addressed the analysis of R&D alliances by distinguishing between exploitative and explorative collaborations (Faems et al., 2005; García-Granero, et al., 2014). While the former is oriented to enhancing existing competences, the latter is aimed at creating new ones. Thus, explorative collaborations are accepted to be especially successful in the creation of products with a high degree of novelty or in the development of new technology in the form of patents; exploitative collaborations are related more to the improvement of existing products. To a large degree, this idea also goes hand-in-hand with the distinction between complementary versus supplementary knowledge. While supplementary knowledge may fit better with the firm's current knowledge base and can be expected to improve existing organizational competences, complementary knowledge is more likely to provide new ideas that lead to the development of new projects and use of existing skills in different ways (Knudsen, 2007). Traditionally, universities have been considered a source of complementary knowledge for the firms and, therefore, collaboration with these agents is considered to be of a more explorative-oriented nature.

However, in the light of the discussion presented in the previous section, the question that emerges is how the organizational form adopted for managing university-industry relationships influences the explorative nature of this relationship. In this sense, the underlying premise in this work is that the type of relationship (contracting or cooperation) may have different effects on innovative performance according to the degree of novelty of the innovation outcome. Since the literature on these effects is scarce, the present study does not state specific hypotheses but comments on the results.

Methodology

Exploiting Panel Data

The empirical analysis uses six waves (2004-2009) of the Spanish Technological Innovation Panel (PITEC). Like other Community Innovation Surveys, the PITEC is based on the OECD's Oslo Manual. The unit of analysis is the single enterprise, whether an independent firm or part of a group. We restrict the analysis to the manufacturing industry.

We exploit the panel structure of the data to account for unobserved heterogeneity by means of conditional fixed effects (CFE) models. Fixed effects are factors that remain constant over time yet may influence innovation and be particular to each individual firm, such as proximity to a world-class university, organizational structure, reputation and brand, industry, etc. Accounting for fixed effects reduces omitted variable bias and, along with the inclusion of the dimension of time, provides researchers with a closer experimental approximation (Angrist and Pischke, 2009).

The survey asks firms whether they have introduced a new product or process, invested in innovation, or had ongoing or abandoned innovation activities during the period covered by the survey. A positive answer to one of these questions classifies a firm as innovation oriented. We use this selection criterion to restrict our analysis to the subsample of innovation-oriented firms. This decision was driven partly by the questionnaire design: only innovation-oriented firms fully complete all sections of the questionnaire, including those questions related to cooperation with external agents. Roughly 86% of the firms are innovation oriented. After deleting observations with missing values, we are left with an unbalanced panel of 5858 manufacturing firms over six periods.

Definition of the variables

Dependent variables

This paper uses two dependent variables to estimate the effect of university interaction mechanisms on innovative performance. A pair of variables measure the share of sales from product innovations that are new to the firm (INNFIRM) or new to the market (INNMARKET). These variables provide information on the novelty of product innovation and also how much of the firm sales such innovations account for. There is a fair amount of ambiguity in the literature surrounding terminology and definitions of what constitutes 'incremental' and 'radical' innovation. However, INNFIRM and INNMARKET are understood in the literature to capture the degree of product innovation from less to more novel, respectively. We log transform the variables (after adding 1) to account for skew and satisfy distributional assumptions in the models.

R&D contracting and cooperation variables

Our explanatory variables cover specific university interaction mechanisms, in particular R&D contracting and cooperation. Although the main objective is to analyse firm interaction with universities, we control for the effect of relationships with other commercial agents on innovative performance. To analyse the effect of cooperation we draw specifically on the responses to questions about cooperation with external agents for R&D and innovation activities. We define a set of two dummy variables indicating each of cooperation with universities (COOP_UNI) and commercial agents (COOP_COMM). In order to evaluate the effect of R&D outsourcing we draw on the responses to a question that asks firms to indicate expenditure on R&D services by different external agents. This information allowed the construction of two dummy variables specifying R&D contracting to universities (RD_UNI) and commercial agents (RD_COMM).

Control variables

We control for changes in several firm-level variables, namely the firm size measured in the log of revenue (LSIZE) and a dummy indicating whether the firm has sales in international markets outside of the European Union (INTERNATIONAL). Note that the firm size and market, in general, are controlled for in the fixed effects; these variables control for changes in firm size, such as through a merger or layoff. We include a variable to measure the intensity of internal R&D activities. The variable LEMP_RD is the natural logarithm of the percentage of employees who dedicate at least some of their time to R&D activities.

Estimation Approach

Because many innovation-active firms do not achieve sales from new products, these variables are censored at zero and non-negative. If the censoring is not accounted for, the estimates can be biased. Censoring of a continuous variable expressed as a proportion leads to a significant difficulty in accounting for firm-specific effects (Reitzig and Wagner, 2010). Although a Tobit model is the appropriate estimator in censored cross-sectional analyses, there is no sufficient CFE Tobit estimator (Greene, 2004). Therefore, we compare the results of several econometric approaches.

We first estimate INNFIRM and INNMARKET using CFE ordinary least-squares (OLS) regression. Angrist and Pischke (2009) argue in favour of OLS over non-linear models; OLS does not depend on distributional assumptions of a latent variable and estimates the average effect of each covariate considering that the outcomes are actually zero for many firms. They contend that, while non-linear models in many cases provide accurate predictions regarding coefficient direction and significance within the bounds of true censoring, OLS is standardized, more parsimonious, and can be interpreted directly as average marginal effects.

Next, we estimate the models for INNFIRM and INNMARKET using the semiparametric fixed-effects Tobit. The method artificially trims the data and eliminates the fixed effects through differencing, resulting in a consistent estimator (Cameron and Trivedi, 2010: 808). The distribution of the errors in this method remains unspecified, and no distributional assumption is imposed on the unobservables.

Finally, we estimate the continuous variables with the CFE Poisson. The properties of the CFE Poisson both condition out fixed effects and account for censoring at zero. Even though INNFIRM and INNMARKET are not count data, the CFE Poisson is still applicable to continuous variables in log-log models because it is equivalent to the Generalized Method of Moments (GMM) estimator (Windmeijer and Santos Silva, 1997).

Results

Table 1 presents the definitions, descriptive statistics of the variables - which are reported prior to log transformation – and the pairwise correlation matrix.

Keeping in mind that the PITEC draws from a subset of R&D active firms in the national innovation survey, 12.7% of the innovation-oriented firms engaged in active cooperation with universities. Although not presented in Table 1, 5.5% of firms both contracted R&D to and cooperated with universities concurrently. Stated differently, 43% of firms that cooperated with universities also report contracting R&D to universities. This indicates that firms do not approach these activities as substitutes for one another and may engage in both types of interaction for different purposes.

Table 1. Descriptive statistics and definitions of variables. Mean reported prior to log transformation. Within standard deviation in brackets. Correlation Matrix

Variable	**Mean (*within* s.d.)**	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
(1) INNFIRM	16.571% (20.366)								
(2) INNMARKET	10.741% (16.278)	0.066*							
(3) RD_UNI	0.096 (0.189)	0.027*	0.061*						
(4) COOP_UNI	0.127 (0.202)	0.048*	0.101*	0.433*					
(5) RD_COMM	0.210 (0.276)	0.061*	0.090*	0.208*	0.155*				
(6) COOP_COMM	0.212 (0.264)	0.072*	0.103*	0.177*	0.404*	0.227*			
(7) LEMP_RD	10.435% (9.101)	0.132*	0.213*	0.169*	0.166*	0.177*	0.117*		
(8) LSIZE	5.70×10^7 (8.73×10^7)	0.008	-0.007	0.121*	0.151	0.124*	0.176*	-0.180*	
(9) INTERNATIONAL	0.818 (0.179)	0.053*	0.058*	0.067*	0.078*	0.071*	0.080*	0.067*	0.287*

Table 2 presents the regression results evaluating the effect of university contracting and cooperation of R&D activities on firm innovative performance and the novelty of new products. The explanatory variables of interest are the two formal mechanisms through which firms interact with universities. Models I, III, and V present the results of fixed-effects OLS, Tobit, and Poisson estimations of the sales from products new to the firm (INNFIRM), and models II, IV, and VI present results from products new to the market (INNMARKET). The results are similar across the three econometric approaches in terms of sign and significance, giving us confidence in the robustness of the findings.

Table 2. University Interaction and Degree of Product Innovation

	CFE OLS		FE Tobit		CFE Poisson	
Variable	(I) INNFIRM	(II) INNMARKET	(III) INNFIRM	(IV) INNMARKET	(V) INNFIRM	(VI) INNMARKET
University Contracting	0.083**	0.012	0.134**	0.002	0.052**	0.004
	(0.041)	(0.040)	(0.066)	(0.078)	(0.026)	(0.032)
University Cooperation	0.058	0.118***	0.082	0.195**	0.034	0.087***
	(0.044)	(0.042)	(0.069)	(0.079)	(0.027)	(0.033)
Commercial Contracting	0.040	0.054*	0.063	0.089	0.023	0.036
	(0.031)	(0.028)	(0.050)	(0.058)	(0.019)	(0.023)
Commercial Cooperation	0.146***	0.138***	0.228***	0.269***	0.088***	0.116***
	(0.036)	(0.033)	(0.057)	(0.066)	(0.022)	(0.027)
Log Share R&D Employees	0.055***	0.084***	0.103***	0.196***	0.038***	0.078***
	(0.013)	(0.011)	(0.025)	(0.028)	(0.009)	(0.011)
Log Firm Size	0.019	0.026	0.035	0.045	0.013	0.013
	(0.032)	(0.026)	(0.060)	(0.059)	(0.021)	(0.022)
International	0.017	0.022	0.030	0.065	0.013	0.022
	(0.050)	(0.044)	(0.100)	(0.118)	(0.036)	(0.046)
Year Dummies	Included	Included	Included	Included	Included	Included
Observations	28933	28933	28993	28993	23239	18719
Firms	5858	5858	5858	5858	4384	3472
Log likelihood	-	-	-	-	-27830.94	-21649.44
F-test (12, 5857)	9.12	18.22	-	-	-	-
Chi^2	-	-	116.55	242.47	108.36	208.42
Prob > Chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

*** p < 0.01 ** p < 0.05 * p < 0.1 Robust Standard Errors in brackets. FE

Overall, interaction with universities has a positive and significant effect on the innovative performance of firms. However, the two interaction mechanisms have different effects according to the degree of novelty of product innovation. University contracting is significant only for innovations new to the firm, while the opposite relationship is seen with university cooperation, which is highly significant only for innovations new to the market.

Cooperating with commercial partners is a significant and positive predictor of both types of product innovation. Conversely, contracting to other firms does not predict product innovation (except in for the case of the OLS estimation in Model II, where it is significant only at the 10% level).

Unsurprisingly, internal R&D intensity consistently and positively predicts innovation outcomes. In any case, it is informative to compare the magnitude of the coefficient across the degree of product novelty in Table 2. Returns to internal R&D are higher for product innovations that are new to the market (Model VI) than for those that are merely new to the firm (Model V) as indicated by the larger coefficient.

Discussion

Recently, researches have emphasized the potential for universities as a source of external knowledge in firms' innovation processes (Rajalo and Vadi, 2017). The purpose of this study was to examine the effectiveness of university-industry links as an innovation strategy, paying special attention to those interactions that imply a higher level of relational involvement – namely R&D contracting and cooperation - and taking into account the degree of novelty of the innovation outcome. Several important findings emerge from the analysis.

First, this research finds that high-relational interactions with universities positively predict firm innovative performance. In general, both R&D contracting and cooperation with universities appear as important strategies in order to introduce new products onto the market. This result is consistent with the open innovation literature and other types of network perspectives toward industrial innovation that highlight the prominent role of universities as innovation partners and their capacity to enhance firms' technological performance (Bellucci and Pennacchio, 2016).

Second, and even more important, this research uncovers a distinction between the degree of novelty of innovation outcome resulting from R&D contracting and that from cooperation with universities: contracting predicts product innovations that are new to the firm, but cooperation predicts market novelties. In general, the effect of cooperation with universities on more novel product innovations is consistent with some prior empirical studies (Bellucci and Pennacchio, 2016; Eom and Lee, 2010) and supports the view of university as an important source of complementary knowledge when exploring novel domains of technology. In contrast, the result from R&D contracting partially differs from those in Vega-Jurado et al., (2009b) and Tsai and Wang (2009) on the effectiveness of R&D outsourcing as innovation strategy. Although neither of these studies specifically analyses the contracting of R&D services to universities, all of them find that R&D outsourcing does not have a positive effect on innovative performance and in some cases even suggest a negative net effect. These results have been explained by firms' reluctance to share relevant knowledge because of the threat of unexpected transfer of knowledge to competitors. To be effective, contracting typically requires a bi-directional flow of knowledge insofar as the firm has to give the external provider access to its own knowledge base in order to achieve enhanced performance. In this sense, problems related to knowledge leakage and the opportunistic behaviour of the R&D provider may arise during the task and may compromise the effectiveness of this strategy. In the light of our results, these problems seem to be less sensitive in the case of universities possibly because these agents are not potential competitors and the social norms in academia favor sharing knowledge rather than monopolizing it (Fey and Birkinshaw, 2005).

Another important implication arising from our results is that governance mode matters when considering relationships with universities. Thus different strategies to access university knowledge may lead to different innovative outcomes. So far, most empirical research about university-industry links has addressed these linkages in a very generic way while seldom linking the differences between the specific types of relationships with the nature of innovative outcome. Perhaps as a result, previous research has uncovered multiple and even contradictory findings regarding the role of universities in industrial innovation.

The interesting question at this point is why cooperation leads to more novel innovation outcomes than contracting. There are general differences between these strategies that may shed light on our findings. R&D contracting often takes the form of arms-length, iterative exchanges of explicit knowledge largely codified, for example, in the form of blueprints, contracts or technological packages (Lucena, 2011). Since both parties are responding to specific information, R&D contracting limits the scope to clearly defined problems and solutions. Furthermore, the firm often determines unilaterally the expertise required from the university, such that the relationship is asymmetric in nature (Perkmann and Walsh, 2007). In this way the R&D contract initiated and defined by a firm is less explorative in nature and does not fully access the broad knowledge held in a university. Thus although universities are recognized as having a broad base of easily accessible knowledge, R&D contracting is limited in scope and possibilities for feedback such that firms are not able to take advantage of the full breadth of knowledge in a university to generate market novelties.

On the other hand, R&D cooperation, due to its interactive nature and sharing of resources, promotes the exchange and development of tacit knowledge and exposure to spillovers and heterogeneous knowledge. This may lead the collaboration down a different, explorative path than both parties were able to envision at the outset. Furthermore, cooperation increases the potential for mutual learning because the firm is concerned not only with the knowledge output per se but also with the process of developing that knowledge. Through

cooperation with universities, firms may enhance their knowledge base and create new combinations making new technological breakthroughs more likely. The development of innovations with a high degree of novelty is full of uncertainty and often follows an unforeseeable development path. In this sense, cooperation can allow for ambiguity and adjustment during the development of an R&D project.

On balance, the results of this study highlight that the ability of the firm to achieve a higher innovative performance from its relationships with external agents is a function of both the nature of external knowledge sources and the nature of the relationships forged with these sources. Exploring jointly the effect of these factors therefore appears as a prominent line of inquiry in order to go a step further in the analysis of effectiveness of external knowledge sourcing as innovation strategy.

Limitations and Future Research

Large datasets permit broader generalizability but necessarily omit many idiosyncrasies, such as how the observed relationship may differ according to industrial factors. Future research could seek to understand under what conditions our general results do or do not hold. Further, we have made a number of assumptions based on the literature regarding the nature of the differences in university R&D contracting and cooperation, such as communication patterns and the type of agreements. More detailed research could seek to break down and operationalize differences in contracting and cooperation with universities in order to see how these factors contribute to the innovative performance and novelty of product innovations.

Our research examined an important innovation outcome: sales from innovative products. There may be other tangible and intangible organizational consequences that differ between contracting and cooperation with universities, such as process innovation, appropriability of results, profitability and project costs, time to market, etc. Given that these two modes of formal interaction seem to have fundamental differences in terms of knowledge creation and transfer, future research could explore broader implications for firm performance.

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Disruptive change and the reconfiguration of innovation ecosystems

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Abstract: This conceptual paper extends the traditional view of disruptive change, which considers the effects of rivalry between an incumbent and new entrant firm, by examining the impact of disruption upon the 'innovation ecosystem' in its entirety – the group of organisations that collaborate in creating a holistic value proposition for the end-user. Following Adner's "ecosystem-as-structure" perspective, we develop propositions that anticipate structural differences between incumbent and disruptive innovation ecosystems, and then review these propositions in the context of three historical, disruptive innovation cases; Bakelite (a synthetic plastic), microwave oven, and photocopier. Through these cases, we illustrate that the manner of innovation ecosystem reconfiguration is likely to depend on the design attributes of the product, as well as the type of disruption experienced. We conclude by reflecting upon contemporary cases of disruption enabled through digital technologies, and proposing a framework that can guide future research.

Keywords: innovation ecosystem; ecosystem as structure; disruptive change; value blueprint; bakelite; microwave oven; photocopier.

Submitted: July 7th 2017 / Approved: September 11th 2017

Introduction

A long line of research has addressed the detrimental effects radical changes in the technological landscape can have upon firms (e.g. Tushman and Anderson, 1986; Bourreau et al., 2012; Carlsson, 2016). Following the 'creative destruction' argument of Schumpeter (1942), scholars have developed various frameworks to examine the evolution and revolution of technology-based industries. One of the most prominent frameworks has been introduced by Christensen (1997) to analyse the changes in the industry and the market, subsequent to the emergence of a so-called 'disruptive innovation'. Unable to find a foothold among mainstream customers due to its lack of performance, this new product initially serves a niche segment, beyond the strategic radar of incumbent firms competing for the mainstream market. Over time, however, the innovation attains sufficient performance levels to penetrate the larger customer segments and enter into rivalry with the incumbent technology, often displacing the latter due a different value proposition that is seen to be comparatively better. Unaware of the potential threat caused by the disruptive innovation, incumbent firms are compelled to exit the industry (e.g. Sandberg and Hansén, 2004; Currah, 2007; Da Silva et al., 2013).

Notwithstanding the value of this widely used theoretical model, there is growing interest in the way organisations create value collectively rather than as singular units (e.g. Adner, 2012; Adner, 2017). Hence, while the disruptive innovation framework is able to explain the consequences of radical innovations upon individual firms, there is need for greater understanding of the influence of disruption upon the larger, systemic context (see Adner and Kapoor, 2016a for a recent treatment of this issue). We subsequently aim to conceptualise the impact of disruption upon the 'innovation ecosystem', which connotes the heterogeneous set of organisations whose interactions deliver a holistic value proposition to the end-user (Moore, 1993; Garnsey and Leong, 2008; Brown, 2016). In line with Christensen's contributions, which have been to divulge the mechanisms of disruption and the derivation of implications for the incumbent (and disrupting) firm, our paper aims to illuminate how the innovation ecosystem changes subject to its disruption by a radically new technology, and arrive at implications for the firms that constitute the ecosystem. We feel this to be highly valuable for practitioners in particular, providing a more comprehensive analytical lens in their evaluation of the competitive environment.

Our conceptualisation essentially extends the traditional view of disruption as that resulting from the rivalry between incumbent and disrupting firms, to that ensuing between incumbent and disruptive innovation ecosystems. To understand the systemic effects of disruption, we employ the notion of the 'value blueprint' advocated by Adner (2012), which denotes the schema of actors and their connections necessary to deliver the innovation ecosystem's value proposition. Following Adner's (2017) suggestion that specific value propositions are delivered by unique ecosystem structures, we establish the premise that the value blueprint of the disruptive innovation ecosystem will be inherently different to that of the incumbent innovation ecosystem. Hence, from the perspective of any given actor in the ecosystem, the advent of disruption will essentially reconfigure the incumbent value blueprint as actors and their connections are necessarily adjusted. Some of these alterations may be detrimental while others reinforce the position of actors.

In our conceptual work we discuss the variables that may explain such reconfiguration, and derive propositions to explain how innovation ecosystem value blueprints are altered subsequent to disruptive technological change. We then review these propositions in light of three illustrative cases of disruptive innovation, namely, Bakelite (a fully synthetic plastic), the microwave oven, and the photocopier. In each of these cases, we use historical data to compare the value blueprints of the incumbent and disruptive innovation ecosystems. This

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comparison essentially describes the reconfiguration of the incumbent ecosystem subject to disruption, as actors are added, subtracted, relocated, combined, or separated. In this manner, our work extends Adner's (2017) recent contribution that focuses more generically on the delivery of a new value proposition bought about by ecosystem structure reconfiguration. We conclude our paper by reviewing our conceptually derived propositions and illustrations, to propose a stylised framework, which can guide future research endeavours.

Theoretical background

Innovation ecosystems

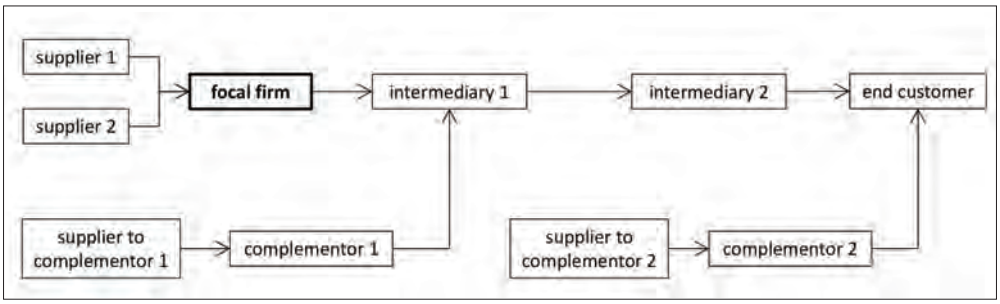
The innovation ecosystem can be broadly defined as a set of organisations, which produces a holistic, integrated technological system (e.g. personal computers, smart watches, and online marketplaces) that creates value for customers (Teece, 2007; Agerfalk and Fitzgerald, 2008; Basole, 2009). This heterogeneous coalition may include suppliers, complementors, system integrators, and customers, together with distributors, advertisers, finance providers (e.g. venture capitalists, corporate investors, investment bankers, and angel investors), universities and research institutions, regulatory authorities and standard-setting bodies, and the judiciary (Whitley and Darking, 2006; Iyer and Davenport, 2008; Pierce, 2009;). Collectively, these actors "co-evolve capabilities around a new innovation" by working cooperatively as well as competitively in the creation of products and services (Moore, 1993). The mobile phone ecosystem (Basole, 2009), Amazon's web service ecosystem (Isckia, 2009), and Google's innovation ecosystem (Iyer and Davenport, 2008), are just some examples of ecosystems that centre on respective innovations.

Commensurate with its biological metaphor origins, some scholars have emphasised the indispensability of the 'keystone' (Iansiti and Levien, 2004) or 'platform leader' (Cusumano and Gawer, 2002) that lies at the core of the innovation ecosystem. The keystone's role is to regulate the overall function of the ecosystem and as a consequence its actions influence the success of all other members. Firms such as Microsoft, Apple, and Mozilla have been crucial platform leaders, ensuring the continued development of their respective ecosystems (Cusumano and Gawer, 2002; Tiwana et al., 2010). The keystone is supported by a further category of actors referred to as 'niche players', which undertake specialised functions. Niche players can also be referred to as 'complementors' given that their specialised contribution is complementary to the core function of the platform leader, and which helps expand the realms of the latter's products and services. In this manner, by focusing on the "communities of associated actors defined by their networks and platforms affiliations" (Adner, 2017, p.40), scholars assume what Adner (2017) refers to as an "ecosystem-as-affiliation" perspective of innovation ecosystems.

In this paper, we predominantly employ the alternative, "ecosystem-as-structure" perspective of the innovation ecosystem advanced by Adner (2017), underscoring the "configurations of activity defined by a value proposition" (Adner, 2017, p.40). Lying at the core of this view is the ecosystem's value proposition, which defines the benefits that the end-user will accrue from acquiring the final product. In turn, the value proposition defines the set of actors whose interactions and alignment structures (i.e. defined positions and activity flows) will ultimately bring the proposition to fruition (Adner, 2017). It therefore follows that even when the same set of actors are involved, reconfiguring the ecosystem's structural alignment will deliver a different value propositions, and therefore denote two different ecosystems.

To assist organisations in recognising the ecosystem surrounding them and analysing the process of value creation, Adner (2012) additionally proposes the notion of a 'value blueprint'. Specifically, the value blueprint is a schema of the actors and the connections between these actors that constitute the innovation ecosystem. Within in this schema, we can identify three generic categories of actors with respect to a focal firm: (i) suppliers (i.e. upstream actors), whose products are integrated into the focal firm's own offering; (ii) complementors (i.e. actors off the direct-path of value creation), whose products complement that of the focal firm; and (iii) customers, (i.e. the downstream actors, including intermediaries) who integrate the offering of the focal firm and complementors to acquire enhanced value. The basic, generic unit of the innovation ecosystem value blueprint is shown in Figure 1.

Figure 1. Generic value blueprint (adapted from Adner 2012, p. 87).



While the traditionally used value chain (e.g. Porter, 1985) and supply chain (e.g. Simchi-Levi, 2005) depictions "tend to focus on the linear sequence of handoffs from suppliers to producers to distributors to end customers, the value blueprint is explicit about the specific location and links of complementors that lie off the direct path to market but are nonetheless critical for success" (Adner 2012, p. 84). A significant benefit of the value blueprint framework is the identification of the location risks, or potential bottlenecks, which can curb the

development of the ecosystem as a whole. The removal of these blockages emerges as most pertinent in promoting ecosystem evolution (Adner and Kapoor, 2010; Mäkinen and Dedehayir, 2013).

The interdependence of ecosystem members and the products they contribute is therefore a prime driver of ecosystem development. Under these circumstances, the presence of a clear platform architecture promotes co-evolutionary processes in ecosystems where complementors and component makers produce distinct technological sub-systems (Li, 2009). The platform leader plays a central role in this change dynamic, and has strong motivation to design the ecosystem's architecture, which must be done by forecasting future changes given the often irreversible nature of platform architecture (Tiwana et al., 2010). Such platform design can be aided by 'decomposition', which connotes the breaking down of the architecture in a hierarchical manner into its constituent sub-systems. The benefit of decomposition is the reduction of interdependence between the evolutionary processes of components that make up the ecosystem, which in turn accelerates the evolution of sub-systems while concurrently reducing ecosystem complexity (for a recent discussion of interdependence and timing issues in ecosystems see Adner and Kapoor, 2016b). An element that is central to the design of architectures is therefore the degree of independence between subsystems, referred to as 'modularity' (e.g. Baldwin and Clark, 2003).

Platform architectures can vary from highly modular to highly integrated in their designs. Architectures that classify in the latter end of the spectrum face the challenge of cascading effects as changes in one sub-system are reverberated throughout the ecosystem. Platform leaders that design platform architectures can increase modularity by decoupling sub-systems and standardising the interfaces between them such that they are predefined and stable. Following the arguments of modular systems theory (e.g. Schilling, 2000), we may infer that innovation ecosystems displaying a high degree of modularisation are likely to experience a higher rate of evolution, because modules can evolve independently of others, with less need for coordination and understanding of the internal functioning of other modules. At the same time, the costs incurred in coordination and management of dependencies with other modules and the platform is reduced in modular ecosystems, which once again benefits the evolution of modules and the ecosystem as a whole (Tiwana et al., 2010).

Disruption of innovation ecosystems

Disruptive innovations cause paradigm shifts and establish new trajectories of technological improvement (e.g. Bower and Christensen, 1995; Christensen, 1997). Because a disruptive innovation initially lacks the performance levels necessary to compete with the incumbent technology along value dimensions that are most pertinent to mainstream customers, it is nurtured in a separate (e.g. nascent or emergent) market that appreciates a different value proposition. However, through a series of improvements, the disruptive innovation attains the necessary performance levels valued by the mainstream market, and offers a competitive solution to that of the incumbent technology. Moreover, the disruptive innovation is highly competitive among mainstream customers because it additionally carries the value proposition that has been central in its initial nurturing market.

Disruption triggers a period of competition among the firms that provide the incumbent and disruptive innovations, potentially resulting in the incumbent firms' replacement by the firms that introduce the new innovation. Christensen's description of disruptive change subsequently has profound implications for the incumbent firm, however, the impact of disruption upon the actors that are directly (or indirectly) connected with the incumbent firm – i.e. the incumbent innovation ecosystem – is not considered in this description. To understand the impact of disruption on the incumbent innovation ecosystem, we begin by considering its value blueprint depicted in Figure 1. Following the "ecosystem-as-structure" perspective (Adner, 2017), this schema presents the constellation of organisations that collaborate in delivering the incumbent value proposition to the end-user. However, the introduction of a disruptive innovation brings with it a radical shift in the attributes appreciated by customers in this market, commensurate with Christensen's (1997) framework. This new value proposition will be delivered by an innovation ecosystem that is different from the incumbent with respect to its structure, in other words, the position of actors and the flow of activities between them, no matter whether the same actors are present or not (Adner, 2017).

The emergence of a disruptive innovation thus brings two innovation ecosystems into rivalry, and the succession of the disruptive ecosystem over the incumbent establishes a new structure of actors and connections – essentially reconfiguring the incumbent ecosystem's value blueprint. This reconfiguration can be brought about by: (i) 'relocation' of actors and the tasks allocated to them; (ii) 'separation' of a single task into separate tasks to be undertaken by different actors; (iii) 'combination' of separate tasks to be undertaken by a single actor; (iv) 'addition' of new actors to undertake tasks that are currently absent but would benefit the ecosystem; and (v) 'subtraction' of existing actors and their tasks to benefit the ecosystem (Adner, 2012). Through these reconfiguration mechanisms, we may, for instance, anticipate the replacement (i.e. subtraction followed by addition) of the incumbent focal firm in Figure 1 by the focal firm of the disrupting ecosystem, when the product of the latter substitutes for that of the former. This process aligns with Christensen's model, which considers the rivalry between the incumbent firm and new entrant. However, for the other actors that constitute the incumbent ecosystem (i.e. lying upstream, downstream, and in complementary positions in the ecosystem's value blueprint), we suggest that the manifestation of relocation, separation, combination, addition, or subtraction processes will be governed by two key factors: (i) the nature of the disruptive innovation; and (ii) the degree of modularity of the incumbent product or service.

The traditional mode of disruptive change described by Christensen (1997), referred to as low-end disruption, is characterised by the lower unit price and design simplicity of the disruptive innovation in comparison to the incumbent. Through these product traits the disruptive innovation attracts the price-sensitive segments of the mainstream market at first, and then gradually captures the less price-sensitive segments due to its comparatively better value proposition. We consider two pathways along which the innovation ecosystem' structure can be reconfigures to deliver this new value proposition, which emphasises the reduced price and complexity of the product or service.

First, the ecosystem structure can attain efficiency and economies of scope by dispensing with redundant processes while combining other processes (e.g. through insourcing, and merger and acquisition activities). The value blueprint of the disruptive innovation ecosystem will therefore be simpler, pronounced by a lower number of actors and connections in comparison to that of the incumbent ecosystem value blueprint. Combination and subtraction are likely to be the dominant modes of ecosystem value blueprint reconfiguration when following this pathway. Second, and somewhat in contrast to the first pathway, the price and design benefits can materialise from the introduction of a platform architecture and increased modularisation (Gawer, 2014; Gawer and Cusumano, 2014). Following this pathway, unit price reduction and product design simplicity results from the division and distribution of multiple tasks previously undertaken by a single actor to a number of specialised actors (e.g. through outsourcing activities). Separation and addition are likely to be the dominant modes of ecosystem value blueprint reconfiguration when this second pathway is followed.

In light of the two reconfiguration pathways we have considered, the natural line of inquiry pertains to the conditions that promote one pathway in preference to the other. We argue that an incumbent innovation ecosystem, which delivers a product or service that is modular rather than integrated in its design, will be more susceptible to disruption by an innovation that is platform-based and boasts an even higher degree of modularity – thus promoting the second pathway. In this instance, we suggest that the modular design of the incumbent product or service essentially sets the precedent for the disruptive innovation, which can readily accentuate and refine this modular concept. The reduced unit price and complexity of the disruptive innovation can therefore be achieved through an ecosystem structure that centres about a distinct, core platform, for which a multitude of modules can be developed by numerous actors who specialise in the provision of complementary assets (Teece, 1986; Sawhney, 1998; Gawer, 2014). By contrast, we argue that the disruption of an incumbent product or service, which is not modular in its design, cannot be as readily attained through such platform and modularisation strategy, given the greater difficulty in its decomposition. Other strategies are therefore likely to be sought to lower price and reduce design complexity – thus promoting the first pathway. These arguments lead us to make the following propositions with respect to the reconfiguration of the innovation ecosystem value blueprint.

> *Proposition 1: The reconfiguration of the incumbent innovation ecosystem value blueprint, subsequent to low-end disruption, is likely to be characterised by separation and addition when its product or service is modular.*

> *Proposition 2: The reconfiguration of the incumbent innovation ecosystem value blueprint, subsequent to low-end disruption, is likely to be characterised by combination and subtraction when its product or service is not modular.*

These propositions extend the effects of low-end disruption to the innovation ecosystem in its entirety. In Proposition 1, we suggest that new actors are likely to enter the ecosystem, especially as complementors to the platform leader, when the incumbent product or service is modular. By contrast, Proposition 2 offers caution to incumbent suppliers, intermediaries, and complementors, which face the possibility of exiting the ecosystem with the advent of disruption, when the incumbent product or service is not modular.

Further to the traditional, low-end disruption discussed so far, Christensen and Raynor (2003) underline an additional mechanism through which an incumbent firm faces disruptive competition. This second type of disruption – referred to as new market disruption – does not bring the incumbent and the new entrant into direct competition. Rather, in the words of Christensen and Raynor, "new market disruptions compete against non-consumption" and not the incumbent. In this manner, the period following the inception of the new market innovation is marked by the creation of consumption. As the innovation's performance improves, customers from the traditional market gradually migrate to the new context that had been marked by non-consumption at its outset. The response of incumbent firms to the creation of a new market is one of ignorance, eventually leading to their downfall as the traditional market is siphoned away. This mechanism is different to that of low-end disruption, which is pronounced by the disruptive innovation's invasion of the mainstream market with a low-cost business model, forcing incumbents to flee to higher segments of the market. Christensen and Raynor (2003) add that many disruptive changes are hybrids of low-end and new market disruption, whereby, having created a new market, the disruptive innovation begins to attract and pull the lower echelons of the mainstream market.

Unlike low-end disruptions, new market disruptions do not necessarily compete on lower price. As a consequence, the incumbent innovation ecosystem faces competition from a new market or hybrid disruptive innovation, which offers a better value proposition in the eyes of the customer, despite its higher unit price. Such a value proposition may, for instance, provide additional product or service features, or enhance the functionality of existing ones. Under these conditions, we argue that the comparatively better value offering is likely to result from the addition of complementary assets to the disruptive innovation ecosystem structure. We subsequently offer the following proposition with respect to the reconfiguration of the innovation ecosystem value blueprint.

> *Proposition 3: The reconfiguration of the incumbent innovation ecosystem value blueprint, subsequent to new market disruption created by an innovation of higher price vis-à-vis the incumbent, is likely to be characterised by addition.*

This proposition suggests that new market disruptions can provide opportunities for new businesses to enter the innovation ecosystem, following a similar logic to that of Proposition 2. Especially when the product or service is modular in its design, we posit that these new entrants are likely to assume complementary positons that enhance the value offering of the platform leader.

Illustrations

To examine our propositions, we selected three illustrative, historical cases to provide contrasting results. These cases were drawn from different contexts, and allowed us to access rich information to study the value blueprint reconfigurations of respective innovation ecosystems. We firstly focus on Bakelite, and its use as an electric insulator that rendered it a disruptive innovation, and which changed the market hitherto dominated by Shellac, a natural material with isolating properties. Secondly, we look at the microwave oven, a disruptive innovation that changed customer demand in the cooking market by enabling fast cooking and allowing preparation of ready deep-frozen meals. And we thirdly examine the Canon photocopier, which emerged as a disruptive innovation through its much simpler design with respect to the incumbent Xerox copier.

For each illustrative case a systematic literature search was performed using keywords representing the names of the innovations (i.e. Bakelite, microwave oven, and copier) and additional keywords such as 'history' and 'diffusion' to filter the acquired literature. In turn, the cases were studied systematically to address the following aspects for each instance of disruption:

i. description of the incumbent technology, and its ecosystem value blueprint prior to being challenged by the disruptive innovation

ii. historical account of the disruptive innovation's development and the creation of the disruptive innovation ecosystem

iii. review of the innovation ecosystem value blueprint reconfiguration

Bakelite

Bakelite is one of the first fully synthetic plastics, and like other materials, has been used in many applications. We will focus on a particular episode in the history of Bakelite, namely, its use as an insulator of electric wires, which illustrates the disruptive nature of the innovation as it entered competition against Shellac, a natural material traditionally used for this same purpose.

Description of the incumbent technology (Shellac)

Shellac is a natural material produced by an insect. The lac that is produced by the insect is left on branches of trees that host the insect. At first the lac was seen as a dye, but when aniline dyes were discovered, the lac was more and more applied as a kind of varnish from the late 19th century onwards (Hicks, 1961), used for many purposes (Parry, 1935; Hicks, 1961). Some of the applications of Shellac include its use as an essential component in phonograph records, as an electrical insulating material, and as an ingredient in the making of hats and grinding wheels (Hicks, 1961). For the purposes of this study, however, we focus our attention on the use of Shellac as an electric insulating material.

In the 19th century electricity and electronics became increasingly important in our society. In the second half of the 19th century telegraphy and later telephony required insulation of electric wires (Huurdeman, 2003). In the late 19th century a greater number of cities in the US and Europe were equipped with electricity networks and many rural areas were equipped with local electricity networks (Righter, 1996). All of these activities required considerable amounts of insulating material. Shellac had unique properties in this respect.

The production of Shellac as a natural material was mainly based in specific regions in India. The process of cultivating the material, taking the lac from the branches, preparing and refining the material, gathering and transporting the lac, trading it to Europe or the US entailed a complete and fine-branched network (Parry, 1935). After the transport from Calcutta, India, (the regional trading and transport centre near production) to London, UK, (the regional centre where Shellac was sold to users in Europe) the material could be further refined and reworked into phonograph records, insulation for electric wires, and so on.

The increasing demand and the limited supply of Shellac drove up the price of the material, however, which was further exacerbated during the Second World War. Shellac had many military applications and because of its strategic importance the supply of the material came under Government control. When these controls were lifted after the war, the prices rose to a prohibitive level for uses such as record production, thereby stimulating the search for synthetic resins (Hicks, 1961).

Development of the disruptive innovation (Bakelite)

In the second half of the 19th century many scientists and practitioners tried to create plastic-like materials. At first these materials were based on cellulose that was treated with chemicals. From these efforts materials such as Rayon, Celluloid and other semi-synthetic materials were created (Kauffman, 1993; Townsend, 1993). Later on, precursors of the fully synthetic plastics were created such as Parkesine but these materials were unsuccessful in the market. Bakelite was one of the first successful synthetic materials.

Baekeland, the chemist who developed Bakelite, recognised that the demand for Shellac would outpace supply because of the increased importance of electricity in Western Societies and the limitation in supply. He started to work in a barn behind his house in 1904 and was able to create the first true plastic in 1907. Small-scale production of the plastic began from the same location. Later on in 1911, when demand grew, large-scale production started in a factory.

> *'Baekeland's first patent in the field had been granted in 1906; in all, he took out more than 400 patents related to the manufacture and applications of Bakelite. He started semi-commercial production in his laboratory and, in 1910, when daily output had reached 180 litres, (most of it for electrical insulators), he formed a U.S. company to manufacture and market his new industrial material. By 1930, the Bakelite Corporation occupied a 128-acre plant at Bound Brook, New Jersey.'*
>
> (http://www.acs.org/content/acs/en/education/whatischemistry/landmarks/bakelite.html#invention-of-bakelite)

The disruptive nature of Bakelite was born from its good performance, but most importantly, from its potential to be produced in an industrial process. This production characteristic had two positive effects. Firstly, the potential for higher supply quantity lowered the price of the new technology with respect to that of the incumbent Shellac. Secondly, the capacity to control the production process meant that higher consistency in quality could be obtained. This value attribute could hardly be provided by the natural material Shellac, the quality of which depended heavily on its geographic origin of the raw material and the conditions of the particular season in which this material had been cultivated. The quantity and quality performance attributes displayed by Bakelite were initially valued by the emerging electrical and automobile industries, which required extraordinarily high resistance to electricity, as well as to heat and chemical action.

Reconfiguration of the innovation ecosystem value blueprint

From the description above, we are able to discern some of the key actors that constituted the incumbent ecosystem centring on Shellac technology. Positioning the value blueprint about the focal firm as the actor that produces insulation for electric wires using Shellac, the direct customers appear to be the firms that provide electricity networks (electricity providers). Upstream from the focal firm, there is a complex network of suppliers responsible for the cultivation, collection, and refinement of the material (e.g. in India), as well as actors engaged in intercontinental transportation of this material and local distributors of this material that may supply directly to the focal firm.

We observe a rather substantial reconfiguration of the incumbent value blueprint when we contrast it to that of the Bakelite ecosystem at the time of disruption. The value blueprint created about the disruptive Bakelite innovation began with Baekeland's invention, and gradually increased in the number of actors as large-scale production was attained. The fully synthetic nature of Bakelite, in stark contrast to the natural material that forms Shellac, created an ecosystem that was largely locally based. Together with this, the modern industrial system necessary to produce Bakelite rendered the actors needed to cultivate, collect, and refine raw materials redundant, as well as the actors associated with long distance transportation. The disruption of the Shellac innovation ecosystem by Bakelite subsequently had severe effects on the survival of actors upstream from the focal firm.

The microwave oven

The value proposition of the microwave oven was a new, very fast way of cooking. The first microwave ovens were applied in market niches where speed was considered as an important value attribute and space was limited, such as in restaurants, trains, and ships. These performance attributes, which were central to the development of this innovation eventually changed the traditional market for cooking in households.

Description of the incumbent technology (traditional ovens)

Prior to the advent of the microwave oven, the traditional cooking technologies included cooking stoves and ovens fuelled by gas and electricity, as well as barbeques or grills that burned coal and wood. We consider these as the incumbent technologies that were (partially) disrupted by the microwave oven innovation. These incumbent appliances (still continuing their market presence, albeit for slower, more intricate cooking procedures) work on several principles. The dominant principle is that water is heated and food is boiled, but other principles such as steaming, grilling or roasting are also traditionally used. These principles of cooking nevertheless require a lot of energy and time.

Development of the disruptive innovation (microwave oven)

The innovation of the microwave oven was made possible with the discovery of a crucial component in the early 20th century, namely, the microwave tube. Remaining merely as an invention in its early days, the worldwide economic depression of the late 1920s and early 1930s forced power tube manufacturers to explore new applications for the microwave tubes.

> 'There is some reference in the "early history of industrial electronics," (..) to the fact that the principal high-power tube manufacturers were forced by the depression years to find new tube applications and some of these were in heating—mostly in induction heating and early diathermy work.'
>
> (Osepchuk, 1984, p.1202)

Several market niches that could transform the invention into a commercialised innovation were explored by the firm Raytheon. Military application was one of the most promising, whereby microwave tubes were applied in radars during the Second World War. However, the end of World War II would vanish Raytheon's lucrative military contracts. The accompanying revenue drop required Raytheon to explore new civilian applications (Hammack, 2005). Among other possible civilian applications, employing microwave principals for cooking was a radically new idea.

> 'The commonly used radio wave frequency is roughly 2,500 megahertz (2.5 gigahertz). Radio waves in this frequency range have an interesting property: they are absorbed by water, fats and sugars. When they are absorbed they are converted directly into atomic motion -- heat. Microwaves in this frequency range have another interesting property: they are not absorbed by most plastics, glass or ceramics. Metal reflects microwaves, which is why metal pans do not work well in a microwave oven. In microwave cooking, the radio waves penetrate the food and excite water and fat molecules pretty much evenly throughout the food. There is no "heat having to migrate toward the interior by conduction". There is heat everywhere all at once because the molecules are all excited together.'
>
> (Osepchuk, 1984, p.1201)

Having found a civilian application for the microwave tube, namely cooking, the microwave oven entered market niches where its functional attributes (speed of cooking and smaller space requirements) were appreciated. In time, the microwave oven was able to enter the mainstream market of household cooking, and upon entering changed the value perception of this market. With its capacity to cook as well as the incumbent technologies (ovens and stoves), it introduced the added benefits of convenience and speed that enabled it to gain a stronghold in household kitchens. Moreover, convenience was not only provided by the speed of cooking per se but also by the opportunity to quickly prepare deep-frozen meals. Nevertheless, the first microwave ovens were rather expensive and therefore attracted the less price-sensitive segments of the mainstream market initially. Over time, however, with lowering of prices, the innovation was able to penetrate into the more price-sensitive segments as well.

Reconfiguration of the innovation ecosystem value blueprint

The comparison of the incumbent and disruptive value blueprints reveals some important differences. The value blueprint of the long established, incumbent technologies are pronounced by the presence of complementors that provide energy sources, such as coal, gas, or electricity, as well as cookware (e.g. oven proof casserole dishes, pots, and pans). In this manner, the end-user integrates the hardware (the traditional oven and stove) with the energy components and cookware to enable cooking. This complementarity extends the value blueprint off the direct path of value creation with the presence of a host of actors that compete in their respective industries.

The entrance of the microwave oven into the household kitchen market does not fully align with the traditional view of disruptive change, however. The innovation offers a different set of value attributes with respect to the incumbent, although it has, for the most part, assumed a complementary role rather than one of complete substitution. Hence, many kitchens have been equipped with both the traditional oven as well as the microwave oven. Nevertheless, the disruptive nature of the microwave oven is manifested in its attraction of many end-users away from the incumbent technologies over time. This process has been enabled by the enhancement of holistic value that the end-user has been able to acquire from the innovation. Most notably, the new principle of cooking endowed by the microwave oven stimulated the innovation of new ways of food preparation and new ways of food packaging. Ready and pre-packaged meals can be frozen and subsequently heated quickly if the proper packaging materials are applied. This emergent chain of food production and packaging (addition of new actors into the ecosystem) aligns with the value attributes of speed and convenience consumers associate with the microwave oven instead of remarkably improved energy efficiency that was considered as key advantage in the original patent application (Osepchuk, 1984). At the same time, some of the actors that have provided cookware for the traditional oven have been able to contribute also to the microwave oven value blueprint by developing microwave safe dishes.

The photocopier

The Canon photocopier disrupted the mainstream market dominated by the incumbent Xerox copier, assuming a highly competitive position through the simplicity of its design. Despite displaying lower performance than the incumbent at the outset, its lower price allowed it to penetrate particular market segments, namely, the SMEs (small and medium-sized enterprises).

Description of the incumbent technology (Xerox copier)

The early photocopier industry was dominated by the prevailing business model of wet photography and dry thermal processing, akin to the 'razor' and 'razor-blade' model. A typical machine would cost around $300 (Chesbrough, 2003). Xerox, the pioneer of photocopier machines based on the electrostatic charge process, estimated that the manufacturing cost of their machines would be about $2000, while the variable cost of supplies would remain roughly the same (Chesbrough, 2003). This created a major challenge for the commercialisation of the technology: the 'razor' was much more expensive while the 'blade' was no cheaper. The company used a different business model to overcome the high equipment cost, offering customers the option to lease. Customers needed to pay a nominal $95 per month to lease a machine, and paid a nominal amount per copy. With this new business model Xerox had essentially taken a bet as it assumed that the number of copies would increase considerably, and only then was it possible to make a profit.

Commensurate with their new approach, Xerox introduced the model 914 to the market in 1959. The 914's business model generated more revenue when more copies were made, which established the logic for Xerox's copier business (Chesbrough and Rosenbloom, 2003). The company focused on high-speed, high-volume machines, which inevitably established the paradigm for technological development within the industry. As it was complex to repair these machines, Xerox decided to use its own sales force to lease as well as to repair the machines, simultaneously dispensing with the requirement of partnerships. Xerox manufactured its products, made its own paper to provide optimal feeding and even provided finance for customers.

Development of the disruptive innovation (Canon copier)

Meanwhile Xerox's monopoly ended abruptly in the late 1960s, when the Federal Trade Commission forced the company to license its patents to competitors. IBM and Kodak entered this newly created industry. Both these companies focused on high-speed, high-volume copiers (i.e. following the same technological trajectory set by Xerox), using a business model similar to that of Xerox. Fundamentally, their strategy was to capture a share of Xerox's market by offering better products or better services at lower prices. Neither of these companies, however, managed to take a decent share in the copier business.

In the meantime, Canon found a way to circumvent Xerox's patents by designing a distinctive strategic position to enter the photocopier industry. In contrast to Xerox, Canon focused on SMEs as its target market and decided to sell its machines through a dealer network rather than leasing them. While Xerox emphasised the speed of its machines, Canon elected to concentrate on affordability and ease of use and repair as its differentiating features. The product design was simplified so customers could replace spare parts and could perform simple repairs. In this way, a dealer network was able to handle the customer contacts.

Canon was also able to correct Xerox's failed attempt at the 'razor' and 'razor-blade' model by asking a modest 'box cost' for the copier and earning higher margins on cartridges. Moreover, Canon continued to depart from Xerox's business model by outsourcing the distribution, service, support, and financing functions (Chesbrough, 2003). Xerox attempted to enter this mass market in response, but learned that the business model was entirely different. In 2001, the company was compelled to abandon its presence in the low-end market, and decided to stick to its original high-end market segment.

The Canon copier subsequently disrupted the market as a cheap and simple alternative to the incumbent copier made by Xerox. It altered the value perception of the mainstream market, emphasising the low price for the copying machine and the convenience of simple procedures required to replace parts of the machine when repairs were required.

Reconfiguration of the innovation ecosystem value blueprint

This case study illustrates a radical shift in the value blueprint of the incumbent innovation ecosystem as it is supplanted by the disruptive ecosystem. The former has been shaped by Xerox's business model which has been pronounced by a high level of internalisation of functions. In addition to producing its own machines, the company had decided to horizontally integrate certain complementary products and services, including paper, leasing, repair, and financing. The resulting incumbent value blueprint had relatively few complementors. In stark contrast, Canon's disruptive value blueprint was marked by a much larger network of collaborators. By outsourcing key functions that Xerox had internalised, Canon was able to reduce the price tag of its copiers. Canon had essentially provided a totally new platform with clear interfacing that allowed modules (products and services) to be readily connected to Canon's core product. This strategy added new actors to the value blueprint both as intermediaries and complementors, dealing with functions such as distribution, service, support, and financing.

Discussion and conclusions

The objective of our paper has been to explain how innovation ecosystems change under the influence of disruptive innovations, and consequently, to identify the variables that may explain the reconfiguration of the ecosystem's value blueprint. In essence, the disruptive process brings two innovation ecosystems into rivalry, whereby the ecosystems provide different value propositions, and therefore have different value blueprints (Adner, 2017). The reconfiguration of the incumbent ecosystem value blueprint through addition, subtraction, relocation, separation, and combination mechanisms, are the results of this rivalry. The Bakelite case, for example, underlined the subtraction of multiple actors in the supply side of the incumbent value blueprint as new actors specialised in industrial production entered the fray. In the microwave oven case we observed the addition of new complementors, and our study of the photocopier case revealed significant reconfiguration of the incumbent value blueprint marked by the separation of tasks that were owned by new actors. The various modes of value blueprint reconfiguration we have divulged through these illustrative cases are presented in Table 1.

Table 1. Innovation ecosystem value blueprint reconfigurations and characteristics of disruption.

Incumbent Innovation	Disruptive Innovation	Blueprint Reconfiguration	Type of Disruption	Mechanism of Disruption	Platform/ Modularity
Shellac	Bakelite	subtraction: exit of traditional suppliers and transporters combination: integration of industrial processes under one roof	low-end	lower unit cost through new production methods and redundancy of transport	No
Traditional Oven	Microwave Oven	addition: entry of pre-packaged food producers	new market	higher unit cost with value adding complementarities	Yes
Xerox Photocopier	Canon Photocopier	separation: division of formerly internalised tasks (e.g. distribution, service, support, and financing)	low-end & new market (hybrid)	lower unit cost through outsourcing to specialised firms	Yes

The illustrative cases demonstrated that the type of disruptive change is a primary determinant of the mode of value blueprint reconfiguration. Two of the cases considered in our paper – Bakelite and the Canon photocopier – underline low-end disruption. In both of these cases, the disruptive innovation offered a lower price than the incumbent innovation, namely, Shellac and the Xerox copier, respectively. The disruptive innovations were able to outcompete their incumbent rivals because of their superior value propositions, which not only delivered relatively lower price tags, but also additional benefits, including quantity abundance as compared to the limited availability of Shellac in the case of Bakelite, and flexibility and ease of usage as compared to the strict operation procedures of the Xerox copier in the case of the Canon photocopier.

When we compare the value blueprint reconfigurations, however, we observe different outcomes. In the Bakelite case, the lower price of the innovation appears to have been acquired through two processes: (i) a radical change in production methods (i.e. a synthetic, industrial process as opposed to the quasi-agricultural process for Shellac); and (ii) the redundancy of transportation links. The impact on the ecosystem value blueprint has been that of combination – bringing together different processes under an industrial roof – and subtraction – elimination of the intercontinental transport system. By contrast, Canon's photocopier achieved a lower unit price, vis-à-vis the incumbent Xerox copier, through its simpler design that enabled the outsourcing of a set of activities (e.g. distribution and service) to other actors. In this manner, the overall value acquired by the end-user remained intact, but the price of the Canon copier itself was competitively lower. The reconfiguration of the value blueprint subsequently emphasises separation, in other words, outsourcing of tasks to different actors. Our cross-case comparison suggests there to be two modes of value blueprint reconfiguration for cases of low-end disruptive change that focus on cost reduction, which align with our Propositions 1 and 2.

The microwave oven, by contrast, is an illustration of a new market disruptive innovation, not having entered direct competition with incumbent technologies (i.e. traditional ovens), but rather against non-consumption, creating a new market for faster cooking. And, at closer inspection, we may classify the Canon photocopier as a hybrid disruptive innovation, which simultaneously carries low-end disruption traits (i.e. a simpler and cheaper alternative to the incumbent Xerox machines), as well as new market disruption traits. In this manner, the Canon photocopier's ability to be easily positioned in offices meant that it established a new market (i.e. for office occupants who could not readily access Xerox copiers), gradually pulling the low-end of the existing market into this new context.

When we evaluate the value blueprint reconfigurations of the microwave oven and Canon photocopier cases, we observe some notable differences. For the former, we see that the unit cost of the innovation is high and the product is unlikely to attract customers on the price attribute alone. Rather, we claim that the consumer's 'net utility threshold', in other words, "the highest price a consumer will pay for a product that just meets her functional threshold" (Adner, 2002), is surpassed due to the systemic value that they are able to garner with the availability of complementary products (e.g. ready deep-frozen meals) and the combined effect that the microwave oven and complementarities have on the ease of storing food and the speed and ease of the cooking process. This complementarity is bestowed by the addition of new actors to the ecosystem's value blueprint, which specialise in providing complementary products. Thus, the higher cost of the disruptive innovation is coupled with (and compensated by) the availability of holistic, additional value the customer is able to acquire. This observation aligns with Proposition 3. By contrast, we observe a different mechanism for the case of Canon's photocopier. Unlike the microwave oven, Canon's product is offered at a lower price with respect to the incumbent, Xerox, and is likely to be less demanding on the consumers' willingness to pay. Hence, we believe that the availability of complementary products and services, additional to those outsourced, is not a vital requirement in this and similar hybrid cases where the new market disruption is brought about by an innovation with lower cost.

The cases we have considered here for illustrative purposes are well known, historical ones. However, we can also extrapolate the above discussion to more contemporary disruptive changes, especially those that have been enabled through digital technologies such as the internet. Take for example the disruption of the traditional hotel and accommodation industry by Airbnb's online service innovation. Airbnb's business model works simply on the possibility of common individuals' capacity to offer a similar value proposition (i.e. overnight accommodation) as traditional hotels, with added benefits such as flexibility of location and variety of accommodation options, but most importantly, a price reduction. Airbnb's online platform allows individuals to assume the role of both accommodation provider (i.e. host) and accommodation seeker (i.e. guest). Hence, Airbnb has adopted a clear example of a two-sided market or an ecosystem platform, where users play the consumer as well as the supplier role (Gawer, 2014; Gawer and Cusumano, 2014). The infamous case of Uber follows a very similar logic, as it provides a (potentially) disruptive business model premised on common individuals' capacity to offer rides to other individuals, a value proposition that is more or less the same as that of traditional taxi companies. However, its disruptive potential, in this instance against limousine services (Christensen et al., 2015), rests on the benefit of convenience, but again most importantly on its price advantage in comparison to the incumbent value proposition.

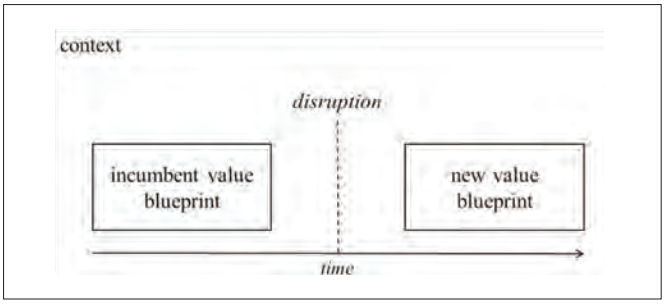
When we compare the contemporary case of Airbnb, and the historical case of the Canon photocopier, we can see differences in the manner of disruption. Following Gawer's (2014) arguments, we perceive Xerox, which had centred its business on an internal platform (i.e. simply as "a firm and its sub-units"), to have been disrupted by Canon, which had developed a supply-chain platform (i.e. an architecture that underlines "an assembler and its suppliers"). By comparison, Airbnb has implemented a different strategy to that of Canon's, in the form of an ecosystem platform (i.e. "a platform leader and its complementors") to disrupt the supply-chain platform of the incumbent hotel business. Notwithstanding these apparent differences, we observe that the direction of change appears to be the same. In other words, in each of the cases considered, the incumbent innovation ecosystem is

disrupted by another that boasts a platform broader in its scope, coupled with increased openness of interfaces, which allow more actors to join the milieu to enhance innovation and diversity of capabilities (Gawer, 2014). This repeating pattern in both historical and contemporary cases affords greater confidence in our propositions related to the low-end disruption of innovation ecosystems.

Future research

We believe that in-depth qualitative studies can examine several types of propositions related to the reconfiguration of ecosystems in addition to the ones that we have started with. To uncover these propositions, we consider a generic process model that comprises the incumbent value blueprint, the type of disruption, and the new value blueprint that results from this disruption, all of which operate in an embedding context (see Figure 2).

Figure 2. Generic process model of value blueprint reconfiguration.



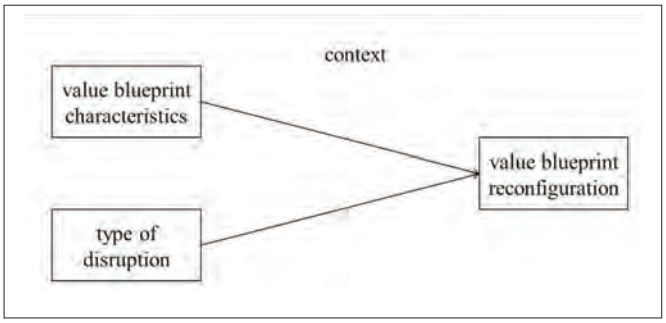
We can derive new propositions for further research by specifying the characteristics or variations of each component in the above figure. For instance, the incumbent value blueprint characteristic that we have emphasised in formulating Propositions 1 and 2 has been the degree of modularity of the incumbent product. This is a logical choice in hindsight as modularity influences the ecosystem's flexibility and adaptability, thus reducing its vulnerability to disruption. However, there are additional characteristics of the incumbent value blueprint that can help us establish propositions related to the manner of reconfiguration, including the structure and the composition of the constellation of actors that make up the entire ecosystem (Adner, 2017). If the value blueprint structure is very rigid with actors that fulfil highly specialised tasks, then disruption might lead to substitution of the entire constellation. By contrast, a more flexible structure where actors can fulfil multiple tasks and be connected via multiple links to other actors, can possibly foster reconfiguration without generating a high rate of obsolescence.

When we consider the types of disruption we specified in our work, we have seen that the new ecosystem can completely substitute for the incumbent, as was the case for the Bakelite vis-à-vis the Shellac ecosystem. In other cases, however (e.g. Canon versus Xerox, and Microwave oven versus the traditional stove), it appears that the new and the incumbent ecosystem can co-exist for prolonged periods of time without substituting each other completely. We think that these outcomes could be taken into account in formulating further propositions, such as those focused on the conditions that favour complete substitution versus co-existence of ecosystems. Another type of disruption that we have not examined in our work, but which has been studied in the wider literature, is the process of 'high-end' disruption (e.g. Govindarajan and Kopalle, 2006; Yu and Hang, 2010). This process describes products that originally enter the high-end niches of a market (i.e. generally with a high price tag and high quality levels), but which later move downwards to disrupt the mainstream market, sketching an opposite direction of movement to the traditional low-end process. We believe that additional propositions could be developed to capture how high-end disruptions differ from low-end disruptions in reconfiguring the innovation ecosystem value blueprint.

Finally, the embedding context can play a vital role in how the incumbent value blueprint is reconfigured subject to disruption. Each of our illustrative cases has drawn attention to this point. For instance, the increase in demand for Shellac originated outside the Shellac market, namely, from the increase of electrical infrastructures and equipment in society, which required more insulating material for electrical wires. In the development of the microwave oven, we observed the impact of the end of World War II, a contextual factor that compelled the exploration of civilian, rather than military, applications for the microwave tube. In the case of the photocopier, Canon's disruptive innovation was essentially triggered in the 1960s when the Federal Trade Commission forced Xerox to license its patents to competitors.

Taking these notions into consideration collectively, we may transform the generic process model of value blueprint disruption (Figure 2) into a simplified static model specifying the causes of value blueprint reconfiguration, as shown in Figure 3.

Figure 3. Stylised model explaining the causes of value blueprint reconfiguration.



The causal model presented in Figure 3 can guide future research initiatives addressing the important issue of ecosystem disruption. Research examining how value blueprint characteristics, and/or the type of disruption leads to reconfiguration can provide valuable insights for incumbent firms making various strategic decisions. Overall, we believe that the ecosystem perspective provides an important avenue for continued research from the practitioner's point of view, in particular. This is because the prevailing theoretical frameworks dealing with the influence of radical, abrupt changes in the technological landscape has hitherto focused on a narrow scope, namely, the ensuing direct rivalry among firms. Yet, firms are embedded in networked environments, collaborating with a host of other actors to

create value to customers in the form of systemic products and services. We therefore believe that the continuation of this line of research will shed light on the competitive position of suppliers, intermediaries, and complementors, as well as customers, when an innovation disrupts an existing ecosystem.

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ISSN: 0718-2724. (http://jotmi.org)

Value contributions of the venture capitalist in Mexico: building an exit for the investment

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Abstract: Venture capitalists provide money and non-monetary contributions to high-growth ventures to help them become great companies. Although it is known that these contributions have an impact on the growth of the firm, little is known in Mexico of their nature, how they get into the venture, and how they contribute to the development of the company. The present article reports a proposed substantive theory that explains how the venture capitalist work hand in hand with the entrepreneur to grow the company. This substantive theory emerged from data collected through interviews to nine venture capitalists and nine entrepreneurs, and analyzed as proposed by the grounded theory methodology. The resulting substantive theory acknowledges that contributions of venture capitalists, often called value-added, are relative to building an exit for the investment.

Keywords: venture capital; venture capitalist; value-added; high-growth venture; high-growth entrepreneur; innovation; high-tech; venture financing; grounded theory; Mexico.

Submitted: July 7th 2017 / Approved: September 25th 2017

Introduction

The venture capital industry was born in the United States of America, U.S.A., in 1946 when the firm American Research and Development was created to invest in technology-based young firms, however it was not until the 70s-80s, mainly due to regulatory changes, when the industry attracted more money and venture capitalists (Gompers & Lerner, 2006). Today, venture capital is recognized as the main source of innovation and new jobs, and the growth engine of an economy (Lerner, 2009). Venture capital is new in Mexico and is in its early-stage of development. From 2010 to 2016, deals closed in Mexico were 522 vs. 59,005 in the U.S.A., and exits in Mexico were 21 vs. 5,981 in the U.S.A. (NVCA, 2017; "Overview of the venture capital industry in Mexico - October 2016," 2017). Due to the attractiveness of this industry worldwide, the Mexican government initiated efforts to detonate the growth of venture capital at the beginning of this millennium. For example, the government created the venture capital fund Fondo Emprendedores CONACYT-NAFIN to invest in ventures based on scientific and technologic breakthroughs in 2004, the venture capital fund of funds Mexico Ventures I to increase the number of independent venture capitalists in the country in 2010, and the seed capital fund Fondo de Coinversión de Capital Semilla to increase the number of viable business opportunities for the venture capital industry in 2013 (Ramírez, 2015). Today, despite these efforts to invigorate the industry that resulted in the creation of 14 venture capital funds ("Estadísticas," 2017), venture capital is referred to as "capital emprendedor" in Mexico, venture capital financing is still barely known in Mexico.

Venture capital is a special kind of financing. The venture capitalist uses money from investors to capitalize very risky business opportunities, most of them with innovative products and services which usefulness has not yet being accepted by the market (Hellmann & Puri, 2000). The venture capitalist knows how to minimize risks and has special knowledge and capabilities to grow ventures (De Clercq & Manigart, 2007). On the other hand, the high-growth entrepreneur creates ventures that, unlike traditional entrepreneurial endeavors, transform innovative ideas into high-value-added products for very large markets (Hellmann & Puri, 2000). Thus, when looking for financing, the high-growth entrepreneur chooses a venture capitalist with the money needed to market his product, and with knowledge and abilities to help him grow his venture (Knockaert, Lockett, Clarysse, & Wright, 2006). The venture capitalist and the high-growth entrepreneur become partners and work together to grow the venture exponentially, in a working relationship that will last for several years.

The venture capitalist - entrepreneur relationship begins when the entrepreneur pitches his business opportunity to the venture capitalist, and often prevails until the venture capitalist withdraws his investment from the company. The venture capitalist is not just a provider of financial resources to the venture, he becomes an owner of a stake in the venture. The initial and dominant approach to study the venture capitalist - entrepreneur relationship reported in the literature was the agency problem (Arthurs & Busenitz, 2003). The belief was that the entrepreneur behave opportunistically due to misaligned objectives and contrasting risk preferences with respect to the venture capitalist. Contrary to opportunistic behavior and self-interest, later the characterization of the relationship was one of trust and collaboration (Leece, Berry, Miao, & Sweeting, 2012). From this perspective, the entrepreneur seeks to improve the performance of the venture because: (a) his interests are aligned with those of the venture capitalist and the organization; (b) he perceives justice in dealing with the venture capitalist and consequently does his best effort; and (c) he has economic motives to cooperate and promote a collaborative

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relationship with the venture capitalist. The new approach suggests that a good venture capitalist – entrepreneur relationship is necessary for the development of the venture.

Despite the fact that activities carried out by the venture capitalist in the U.S.A. are reported in an abundant literature, little is known about the value contributions of venture capitalists. How do they add value to their companies? In particular, what are the venture capitalists' resources transferred to the company? what are the mechanisms used by venture capitalists to add value? and what are the factors that impact on those mechanisms that finally determine the value added to the company? Knowing about how value added is created between the venture capitalist and the high-growth entrepreneur could contribute to open the black-box of the venture capitalist's involvement, and reduce the number of venture capital-backed firms that fail. Gage (2012) places the number of venture capital-backed firms that fail at 75%. Therefore, the objective of this article is to explain the value contributions of the venture capitalist to the venture in Mexico. Following this introduction, the article describes the activities carried out by the venture capitalist reported in the literature, describes the qualitative approach used to analyzed data, introduces the study's participants, presents the substantive theory that emerged from the information provided by the participants, and suggests implications of the study.

Literature Review

The literature on venture capital seeks to understand two main phenomena related to the venture capitalist journey of making a return on his investment: how venture capitalists choose investment opportunities, and how they contribute to grow the venture. In this regard, the venture capitalist not only knows how to choose successful business opportunities but he also knows how to build them (Baum & Silverman, 2004). The following literature review seeks to understand the contributions made by the venture capitalists to grow the venture. Based on the framework proposed by Sapienza & Villanueva (2007), the review focused on the independent venture capitalist, took into account the perspectives from both the venture capitalist and the entrepreneur, and contemplated the activities carried out by the venture capitalist once the cash arrived into the company. Overall, contributions of the venture capitalist are intended to balance the inexperience of the entrepreneur to manage growth, to satisfy the entrepreneur's advisory needs, and to introduce corporate governance into the venture (De Clercq & Manigart, 2007; Large & Muegge, 2008). In the remaining of this section, a differentiation is made between direct and indirect contributions of the venture capitalist. In addition, there is still and ongoing debate on whether the venture capitalist adds value to the venture that is addressed at the end of this section.

Direct Contributions

The venture capitalist contributes directly to the venture by informally participating in meetings with the entrepreneur and through telephone calls and e-mails, to name only a few (Maunula, 2006). The frequency of these venture capitalist – entrepreneur's interactions depends on the characteristics of the venture capitalist, the entrepreneur and the venture. For example, the greater goal congruence between the venture capitalist and the entrepreneur, the more entrepreneur's new venture experience, the greater the geographic distance between the venture and the venture capitalist, the higher the venture stage of development, and the less degree of technical innovation the venture is pursuing, the smaller the frequency of interactions (Sapienza & Gupta, 1994). The formal participation of the venture capitalist in the venture is through the board of directors, often with a controlling position of the company (De Clercq & Manigart, 2007). From the board, the venture capitalist acts like a sounding board, monitors the financial and operational performance of the company, and makes sure that the management fulfills its obligations (Gabrielsson & Huse, 2002).

Large & Muegge (2008) group the most common direct activities carried out by the venture capitalist into matters related to recruiting, mandating, strategizing, mentoring, consulting, and operating. The recruiting activities comprise "advising, doing reference checks, recruiting, negotiation, assessment, and replacement;" mandating activities cover "providing contract and policy terms, control rights, stock rights, contingent rights, performance targets, reports, and controls;" strategizing activities encompass "developing business concept/strategies, doing strategic planning, and keeping focus on longer-term strategic direction;" mentoring activities consist of "providing mentorship, advice, coaching, guidance, facilitation, feedback, motivation, patience, moral support, friendship; acting as confidant, sounding board, and implanting entrepreneurial orientation;" consulting activities comprise "providing business intelligence, contacts, expertise, competence, and teach business skills;" and operating activities include "providing decision making, compensation and incentives, appraisals, discipline, day-to-day hands-on management, professionalization, and managing crises and problems."

Unlike the above activities that mainly seek to add value to the company, monitoring and control activities carried out by the venture capitalist are oriented to protect the value of the investment, and to reduce agency and business risks (Arthurs & Busenitz, 2003). Monitoring activities include observing the operational, financial, business strategy, and product-market performance of the venture (Maunula, 2006). Monitoring cannot be carried out on a continuous basis and it is costly. This high cost of monitoring remote companies may partially explain the tendency of venture capitalists to invest in firms that are close to them (Bernstein, Giroud, & Townsend, 2016). Monitoring the performance of the company helps spot variations according to plan, and controls allow correcting such variations (Kaplan & Stromberg, 2002). Among the most powerful control mechanisms that venture capitalists have are staged financing and replacing the CEO. Staged financing gives the venture capitalist the option of abandoning his effort if he is not certain of the growth potential of the company (De Clercq, Fried, Lehtonen, & Sapienza, 2006), and replacing the CEO, which in most cases means taking away the role of leader from the entrepreneur, is a measure taken by the venture capitalist when the entrepreneur cannot transition to a manager's role (Hellmann & Puri, 2002).

Indirect Contributions

In addition to the so-called direct contributions of the venture capitalist, there are indirect contributions made by the venture capitalist to the company through his business networks and reputation (Davila, Foster, & Gupta, 2003). An important feature of a successful venture capitalist is his specialized business networks and his ability to leverage these business relationships for the benefit of the venture (Bottazzi & Da Rin, 2002). Usually made up of entrepreneurs, lawyers, consultants and experts familiar with recently created firms, his business networks help the venture accomplish goals such as identifying management team's candidates, sourcing strategic information, creating alliances to drive the growth of the company, obtaining additional financing, and reducing information asymmetries in an initial public offering (Campbell & Frye, 2006). His business networks are a scarce resource and have a limited reach, thus the tendency of the venture capitalist to invest in companies in a given geographical location (Gompers & Lerner, 2006).

On the other hand, the reputation of the venture capitalist is related to his ability to generate value. A history of backing successful ventures significantly enhances the reputation of the venture capitalist (De Clercq et al., 2006). The immediate availability of success and failure stories on the Internet and the compact nature of entrepreneurs' and venture capitalists' communities ensure that reputation is improved or damaged without delay (Metrick & Yasuda, 2011). A good reputation brings about benefits to the venture. Talented people are more likely to work in a company funded by a reputed venture capitalist because they perceive the venture has a higher probability to succeed (Davila et al., 2003). Moreover, a prestigious venture capitalist gets loans from banks with better terms (Hellmann, Lindsey, & Puri, 2008), attracts high-quality capital investors and increases the probability to materialize returns for his investors (Kaplan & Lerner, 2010), and obtains higher venture's valuation in an initial public (Bottazzi & Da Rin, 2002). Venture capitalist's reputation also attracts investors. A venture capitalist that delivers results to their investors the first time, will likely continue to appeal to investors for his next endeavor (Metrick & Yasuda, 2011).

Debate Around Value-Added

Although the activities of the venture capitalist have been formally studied, there is still debate about the venture capitalist's contributions to the venture. Research suggests that the venture capitalist contributes significantly to the success of the company through his active participation in growing the venture, and that the value perceived by the entrepreneur and the performance of the venture are highly correlated (Busenitz, Fiet, & Moesel, 2004; Dimov & Shepherd, 2005; Edelman, 2002). Moreover, entrepreneurs believe in the venture capitalists' ability to add value to the venture (Bengtsson & Wang, 2010). Also, the value added by the venture capitalist to the venture impacts positively the results of the company. Companies financed with venture capital perform better that those similar companies without this kind of financing (Campbell & Frye, 2006), and companies backed with venture capital are better valued in an initial public offering (Dolvin & Pyles, 2006). In addition, venture capitalists' investments outperform the public equity market (McKenzie & Janeway, 2011). Finally, contributions of the venture capitalist to the venture are related to innovative developments. An increase in venture capital in a given industry causes a significant increase in the rate of patent registrations in the industry (Kortum & Lerner, 2000).

On the other hand, other research questions the value added by the venture capitalist, whether the firm receives any contribution from the venture capitalist, whether it receives sufficient value, or whether it receives the needed value. How the venture capitalist adds value to the venture remains a focus of debate without consensus in the answers (Bottazzi & Da Rin, 2002), and despite the direct involvement of the venture capitalist in the development of the venture, his contributions are little understood (Wijbenga, Postma, Van Witteloostuijn, & Zwart, 2003). In addition, venture capital backed companies perform no better than non-venture capital backed similar companies (C. K. Wang, Wang, & Lu, 2003). Moreover, when viewed as a process, the non-financial contributions of the venture capitalist are far from being understood since there is no consensus on inputs and outputs nor on their relevance, making it very difficult to improve the efficiency of the venture capitalist's value contributions (Large & Muegge, 2008). Finally, the performance of venture capital is also refuted. For example, the aggregate performance of the venture capital funds is not different from that of the stock market (Kaplan & Schoar, 2005). From above, it becomes evident that there is an opportunity to improve the understanding of venture capitalist's non-monetary contributions to the venture. Thus, explaining how the venture capitalist adds value to the venture will help with this endeavor.

Method

The approach of the study was qualitative and relied on the grounded theory methodology. First, data were collected through interviews with venture capitalists and entrepreneurs from seven venture capital funds in Mexico City and two in Monterrey. The interviews were carried out by the author in person and individually with an interview guide with open questions that was pilot tested with industry's experts. The guide was structured to capture information on whether the venture capitalist added value to the venture, on the nature of the value-added, on the relevance of the value-added, and on the impact of the value-added on the venture's development. Interviews were conducted at the participants' work place to find about their work environment and to achieve high quality audio. During the interviews 1,414 minutes of audio were recorded, 48% of those minutes came from venture capitalists and 52% from entrepreneurs. The study was performed using the transcribed audio that resulted in 503 single-spaced Arial-12 pages. The data were then analyzed with qualitative lens using the grounded theory methodology, as proposed originally by Glaser & Strauss (2006).

The grounded theory methodology is commonly used to study abstract and process-like problems in a given social context (Glaser, 1992). Given that venture capital financing is a complex phenomenon involving frequent interactions between the venture capitalist and the

entrepreneur, and that the venture capital financing phenomenon is barely known in Mexico and rarely researched, more so from the qualitative perspective, grounded theory was the method of choice for analyzing data. From the beginning of the study, the development of a theory with explanatory power was sought. The "glaserian" version of grounded theory used in this study defends the method of discovery where variables and categories arise from data and where each category intertwines with others to bring about the emergence of a substantive theory (Charmaz, 2006). The substantive theory is a theory of intermediate rank that arises from the analysis of data in texts on a particular subject, and can be used as an input to construct formal theories. The study proposes to generate a substantive theory from analyzing empirical data from participants, both inductively and deductively.

The grounded theory methodology offers not only a philosophical direction for the development of a substantive theory but also proposes a method to assist the researcher in all aspects of data collection and analysis, and the writing of the theory (Glaser, 2002). The study used the constant comparison analysis method proposed originally by Glaser & Strauss (2006). This process of analysis is comprised of four stages: (a) the codification and the comparison of incidents; (b) the integration of categories and the definition of its properties, (c) the delimitation of the theory, and, finally, (d) the writing of the theory. At first glance, the method of constant comparison analysis may seem a simple linear process, in practice, however, is a complex process since collection of data and their analysis occur simultaneously. The researcher must return to each of the previous stages as the study progresses, and each stage of the process is an integral part of the development of the grounded theory (Glaser, 1978).

In addition to the constant comparison analysis method, different analysis techniques were used at each stage to assist with the development of the theory. Techniques such as focused and theoretical coding, diagrams, and memos, as described by Charmaz (2006). Open coding was used to identify facts, characteristics, experiences, phrases and explanations that recurrently appeared in the participants' data, and were recorded as codes. By using conceptual codes, focused coding identified preliminary categories, helped name categories, and allowed to saturate or complete categories. Theoretical codification served to relate categories and integrate them into a theory. Following Glaser (1978)'s recommendation for the researcher who starts with data analysis based on grounded theory, the theoretical code used was the Six-Cs, namely, causes, consequences, contingencies, conditions, covariance, and context. This family code fits the model condition-cause-consequence of the present study. In addition, diagrams were used to integrate and to configure and relate categories, and to show the connections between them. Finally, memos, which are records of processes, thoughts, feelings, analytic perceptions, decisions, and ideas related to the study that arise from questions about concepts, were used throughout the study for the writing of the grounded theory. From data arise codes, from codes emerge categories, and from categories emanates the substantive theory. The memos are the basic element that serves to amalgamate these components in search of the grounded theory.

Special care was taken to ensure quality in this study by observing the criteria defined by Charmaz (2006) related to the use of grounded theory methodology for capturing and analyzing data. The participants were the top managers of their organizations; general partners and chief executive officers. Sufficient data was gathered from both parties, venture capitalists and entrepreneurs, to provide a full range of contexts of the study of value-added. Moreover, given that the constant comparison method demands to continuously reviewing the coding of the information, once the data was coded manually, the coding process was repeated several times using the HyperResearch, specialized qualitative research software from Researchware Inc., to re-code data and manage codes. Finally, the results of the study were commented by participants: the resulting categories made sense to practitioners, and provided new insights to the value-adding process.

Results

The nine interviewed dyads, that is, nine venture capitalists and nine entrepreneurs in their portfolios, amounted for 100% of the venture capital funds, 38% of venture capitalists investing in companies in the country, and 27% of the ventures funded with venture capital in 2014. Profiles of the participants and their organizations are shown in Table 1. On average, the venture capitalists are 41 years old individuals, with high level of education, and have two years of funding experience. The size of their funds is $20 million dollars and have two invested ventures in their portfolios. On the other hand, the entrepreneurs are 42 years old individuals with mostly no previous experiences in launching ventures. Their ventures have four years in operation, three of those years with venture capital, employ 70 people, have annual sales of $3 million dollars, and were funded with $2 million dollars of venture capital. From a relationship perspective, two-thirds of venture capitalists are older than their related entrepreneurs, and more than three-quarters of venture capitalists have a higher level of education than their related entrepreneurs.

Table 1. Profile of participants and their organizations

Object / Variable	Relationship #								
	1	2	3	4	5	6	7	8	9
Venture Capitalist									
Years of age	44	40	44	36	37	33	58	51	41
Graduate studies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Years funding ventures	8	2	5	0.5	0.5	4	2	1.5	1.5
Fund									
Years in operation	8	2	5	0.5	0.5	1	3	2	1.5
# Venture capitalists	2	2	4	2	2	2	3	5	2
Employees	10	8	12	6	6	8	5	15	9
Fund size	$20	$20	$100	$20	$5	$20	ND	ND	$70
# Funded ventures	6	2	10	1	3	1	1	1	8
Entrepreneur									
Years of age	60	29	42	52	26	31	29	49	48
Graduate studies	No	Yes	Yes	No	No	No	No	No	No
First venture	Yes	Yes	Yes	No	Yes	No	Yes	No	No
Venture									
Years in operation	4	3	4	6	0.5	4	8	9	9
Years with venture capital	3	0.5	3	3	0.5	4	6	5	1
Annual sales	$3.2	$0.2	$3.1	$2.4	$0.2	$8.0	ND	$28.0	$4.0
Employees	50	6	108	36	7	71	100	650	70
Capital invested	ND	$2.4	$7.0	$2.2	$0.2	$2.0	ND	ND	$2.0

Source: Elaborated by author.

Note: Fund size, annual sales, and capital invested are in million dollars. ND means non-disclosed information.

Codes and categories

Data collected from participants resulted in codes, codes were integrated into categories, and the categories defined a substantive theory. 66 codes emerged from the data. Each of these codes contains words, phrases or concepts with similar meanings. Of these codes, 31 were common to venture capitalists and entrepreneurs, 11 were exclusive to entrepreneurs, 17 were exclusive to venture capitalists, and seven additional selective coding codes from literature completed the categories. To help with the integration of the categories and their relationships, in this section codes are referred to with *italics* and categories with *SMALL CAPS ITALICS*. The codes and their sources are summarized in Table 2. The same table also shows the resulting categories that are addressed in the following paragraphs.

Table 2. Codes and categories generated from participants' data

Code	Source	Category
ability to execute	VC, E	*GROWTH*
active participation	VC, E	*RELATIONSHIP*
advisor	VC, E	*INVOLVEMENT*
appreciation	VC, E	*EXIT*
being receptive	VC	*RELATIONSHIP*
best practices	VC, E	INVOLVEMENT
board member	VC, E	*INVOLVEMENT*
business environment	E	*INVOLVEMENT*
business relationships	VC, E	*ENDORSEMENT*
CEO replacement	L	*INVOLVEMENT*
certainty	VC E	*ENDORSEMENT*
commitment	VC, E	*GROWTH*
common goal	VC, E	*EXIT*
common sense	VC	*INVOLVEMENT*
consultant	VC, E	*INVOLVEMENT*
controls	VC, E	*INVOLVEMENT*
credibility	E	*ENDORSEMENT*
discipline	VC	*INVOLVEMENT*
endorsement	E	*ENDORSEMENT*
execution	VC	*GROWTH*
exit	E	*EXIT*
experience	E	*INVOLVEMENT*
fast growth	L	*GROWTH*
financial return	VC, E	*EXIT*
financing	VC	*INVOLVEMENT*
focus	VC, E	GROWTH
goals' alignment	VC	*EXIT*
incentives	VC, E	*GROWTH*
institutionalization	VC, E	*INVOLVEMENT*
investments	VC	*ENDORSEMENT*
justice	L	*RELATIONSHIP*
key employees	E	*INVOLVEMENT*
knowledge	E	*INVOLVEMENT*
leading company	VC	*EXIT*
mentor	L	*INVOLVEMENT*
milestones	VC	*GROWTH*
money	E	*INVOLVEMENT*
orderliness	VC, E	*INVOLVEMENT*
outsourcing	VC, E	*INVOLVEMENT*
performance feedback	VC, E	*INVOLVEMENT*
performance goals	VC, E	*GROWTH*
performance measurement	VC, E	*GROWTH*
professionalization	L	*INVOLVEMENT*
promotion	VC, E	*INVOLVEMENT*
quality stamp	VC	*ENDORSEMENT*
reason	VC	INVOLVEMENT
relationship	VC, E	*RELATIONSHIP*
reporting	VC, E	*GROWTH*
reputation	VC, E	*ENDORSEMENT*
respect	VC, E	*RELATIONSHIP*
results	VC	*GROWTH*
sale	VC	*EXIT*
sense of urgency	VC	*GROWTH*
shared vision	VC, E	*EXIT*
smart capital	VC, E	*INVOLVEMENT*
sounding board	E	*INVOLVEMENT*
staged investments	VC, E	*INVOLVEMENT*
success stories	E	*ENDORSEMENT*
suitability	VC	*RELATIONSHIP*
support	L	*ENDORSEMENT*
talent	VC	*ENDORSEMENT*
think big	VC	*GROWTH*
timely	L	*EXIT*
transparency	E	*RELATIONSHIP*
trust	VC, E	*RELATIONSHIP*
value	VC, E	*EXIT*

Source: Elaborated by author.
Note: "VC" means data from venture capitalist, "E" data from entrepreneur, and "L" data from literature.

Five categories were integrated from these 66 codes: *ENDORSEMENT* with 10 codes, *EXIT* with 10 codes, *GROWTH* with 13 codes, *INVOLVEMENT* with 25 codes, and *RELATIONSHIP* with eight codes. Table 2 shows the results of coding integration. The integrated categories are described in the following paragraphs.

ENDORSEMENT contains the codes: *business relationships*, *certainty*, *credibility*, *endorsement*, *investments*, *quality stamp*, *reputation*, *success stories*, *support* and *talent*. The category emphasizes that the company financed with venture capital benefits from the *reputation* and *business relationships* of the venture capitalist. The more *investments* the venture capitalist makes, the greater the reach and effectiveness of his *business relationships* and the greater the likelihood that the *investments* will result in *success stories*. More *success stories* increase the *reputation* of the venture capitalist, which translates into stronger *endorsement* and *support* for the venture. A stronger *endorsement* assigns greater *certainty* to the business, attracts *talent* to the venture, increases the *credibility* of the business opportunity, and overall prints a *quality stamp* to the company.

EXIT contains the codes: *appreciation*, *common goal*, *exit*, *financial return*, *goals' alignment, leading company*, *sale*, *shared vision*, *timely*, and *value*. The category accentuates the importance for the venture capitalist to *timely* complete their investment cycle with an *exit*. From the beginning of their relationship, the venture capitalist promotes a *shared vision* with the entrepreneur, seeks *goals' alignment* and makes sure that the *exit* of the investment becomes the *common goal*. To accomplish the *exit*, the venture capitalist captures the attention of potential buyers. He works with the entrepreneur to increase the *value* of the venture and to transform the venture into a *leading company*. At the end, the venture capitalist prepares the company for *sale*, communicates the company's *appreciation* to potential buyers, and sells the firm to get a *financial return* for his investment.

GROWTH is formed by the codes: *ability to execute*, *commitment*, *execution*, *fast growth*, *focus*, *incentives*, *milestones*, *performance goals*, *performance measurement*, *reporting*, *results*, *sense of urgency*, and *think big*. The category emphasizes that the entrepreneur is the one who operates the company and the one who is responsible for the *execution* of the business plan and the growth of the venture. The venture capitalist assists the entrepreneur so that the venture achieves *fast growth*. In particular, the venture capitalist motivates the entrepreneur to *think big* and to execute the development of the company with a *sense of urgency*. In addition, the venture capitalist designs *incentives* to *focus* entrepreneur's efforts, appeals to the entrepreneur's *commitment* to *performance goals* and *milestones*, and, in general, to getting *results*. On the other hand, based on his *ability to execute*, the entrepreneur gets *results*, carries out *performance measurement* of the venture's development, and does the *reporting* of the achieved *results*.

INVOLVEMENT contains the codes: *advisor*, *best practices*, *board member*, *business environment*, *CEO replacement*, *common sense*, *consultant*, *controls*, *discipline*, *experience*, *financing*, *institutionalization*, *key employees*, *knowledge*, *mentor*, *money*, *orderliness*, *outsourcing*, *performance feedback*, *professionalization*, *promotion*, *reason*, *smart money*, *sounding board*, and *staged investments*. The category calls attention to the active participation of the venture capitalist in the development of the venture, both informally and from the board of directors as a *board member*. The venture capitalist relies on his *experience* and *knowledge*, in particular about the *business environment* and *best practices*, to work hand in hand with the entrepreneur to grow the company. In doing so the venture capitalist privileges the use of *reason* and *common sense*. Also, the venture capitalist plays the triple role of *advisor*, *consultant*, and *mentor* for the entrepreneur, hence the venture capitalist's *money* is called *smart money*. Also, the venture capitalist drives the *institutionalization* of the venture by creating a *sounding board*, by introducing *orderliness* and *discipline* into venture's operation, by hiring *key employees*, by encouraging the *professionalization* of the activities, and by *outsourcing* non-core functions. Moreover, the venture capitalist gives *performance feedback* to the entrepreneur, and exerts particularly two kinds of *controls* to ensure the venture performs according to expectations, namely the *CEO replacement* and *staged investments*. Finally, the venture capitalist carries out the *promotion* of the venture, and helps the entrepreneur get additional *financing*.

Last, *RELATIONSHIP* is made of the codes: *active participation*, *being receptive*, *justice*, *relationship*, *respect*, *suitability*, *transparency*, and *trust*. The category underlines the importance of building and maintaining a good *relationship* between the venture capitalist and the entrepreneur throughout the investment cycle. The *relationship* starts when the venture capitalist confirms the entrepreneur's *suitability*, mainly by assessing his ability to execute and his capacity of *being receptive* of venture capitalist's advice to improve his own and venture's performance. *Trust*, *respect* and results are conducive to a good *relationship*. *Trust* is the result of the *transparency* in the venture capitalist - entrepreneur's interactions, and the *justice* perceived by the parties when making decisions. More *transparency* and better perception of *justice* result in a better *relationship*. Also, results achieved by the entrepreneur affect the *relationship*. The *relationship* deteriorates if the company does not get the planned results. Finally, a good *relationship* is related to an *active participation* of the venture capitalist. The above five categories are related to each other, and define the substantive theory described below.

The Substantive Theory

The present study argues that the contributions of the venture capitalist are intended to build an exit for his investment. *EXIT* is the central category and the basic social process that resulted in a substantive theory. The category *EXIT* explains the main issues about the value contributions of the venture capitalist to the development of the venture, and points out the final goal of the venture capitalist's value-adding process that is to provoke an exit. The following examples from participants and the literature highlight the importance of the *EXIT*:

> "The venture capitalist has a clear and evident intention of high profitability because it represents also the commitment he made to his investors. The venture capitalist has to be very profitable for his investors, so the first thing he wants is that the exit is a convenient outcome for his investors." (Entrepreneur # 1)

> "The venture capitalist cares about his exit model, that was very clear to me from the beginning of the negotiations. He had a strong position on that. He wanted a safe way out for his investment." (Entrepreneur # 9)

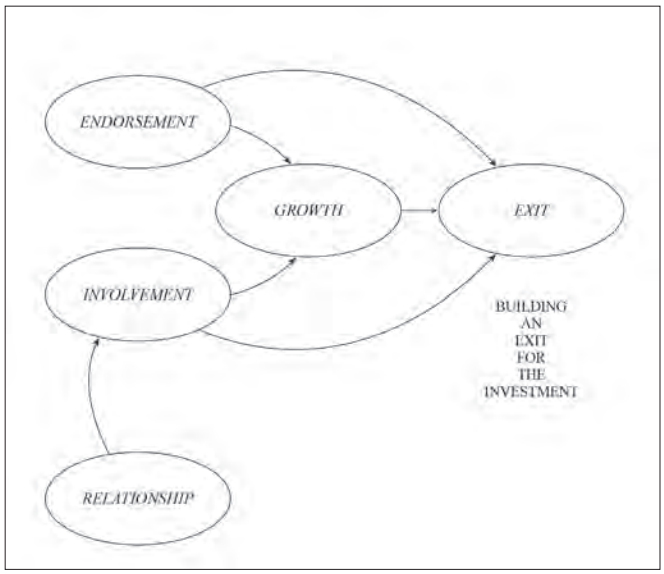
> "VCs' nature is that they need an exit point. This is how they make their money – only on the exits. Therefore, it is not good to them to have a management team that wants to build a perfect company over 20 years. … VCs want out as fast as they can. The minute they buy your share, their only concern is whom they are going to sell their shares to. Short-term profit is not a priority item. It does not matter at all. These are the dippiest, darkest secrets of the VC world." (Ţurcan, 2008)

EXIT is also a basic social process as it is evident in the following observation from one of the participants:

> "The entrepreneur must prove that with the money, he will be able to develop the venture and achieve goals: he needs to make the venture generate positive cash flows; he needs to turn the company into a relevant player in its niche; and he needs to make the company an attractive target for a strategic buyer, or for some other market player, to cause a way out for the investment." (Venture Capitalist # 1)

This basic social process resulted in the substantive theory BUILDING AN EXIT FOR THE INVESTMENT. SMALL CAPS are used here to refer to the substantive theory. This mid-range theory explains a phenomenon in a specific area, how the venture capitalist adds value to the venture, and could possibly contribute to the development of a general theory of universal scope. The theory that arises from the very essence of the data is reported in a simple relational structure shown in Figure 1. The theory has explanation, scope, and relevance for the venture capitalist's value contributions to the venture.

Figure 1. Structure of the Substantive Theory BUILDING AN EXIT FOR THE INVESTMENT



The five categories emerging from the data of the participants are intertwined to BUILDING AN EXIT FOR THE INVESTMENT. The *ENDORSEMENT* effect of the venture capitalist contributes to the *GROWTH* of the venture and enables an *EXIT* event. The reputation of the venture capitalist and his business relationships open doors to the venture and allow the entrepreneur to have access to resources otherwise unavailable such as the talent needed to potentiate *GROWTH*. The stronger the *ENDORSEMENT* is, the higher the prospects to grow. *ENDORSEMENT* also affects the *EXIT* of the investment. The venture capitalist's experience in selling companies helps to effectively carry out activities conducive to the *EXIT* of the investment, such as identifying new investors, and defining and negotiating the terms of the *EXIT*, thus increasing the likelihood of an *EXIT*. On the other hand, an *EXIT* that results in a success story improves the *ENDORSEMENT* effect of the venture capitalist. Venture capitalist's *INVOLVEMENT* influences *GROWTH* and *EXIT*. Although the entrepreneur is responsible for executing the *GROWTH* of the company, the venture capitalist's *INVOLVEMENT* conduces the entrepreneur towards accelerated *GROWTH*. The more *INVOLVEMENT* is, the higher the *GROWTH* of the venture. In addition, the venture capitalist's knowledge and experiences in *EXIT* events increase the probability of an *EXIT*. The more *INVOLVEMENT* of the venture capitalist increases *EXIT* options and improves the chances of obtaining a better yield.

GROWTH of the venture depends on the *ENDORSEMENT* effect of the venture capitalist and on the venture capitalist's *INVOLVEMENT* in the venture. *GROWTH,* in turn, is a condition of the *EXIT* of the investment. Over time, the focused and orderly *GROWTH* increases the value of the venture, attracts potential buyers, and increases the probability of an *EXIT*. The *RELATIONSHIP* venture capitalist – entrepreneur is impacted by the *GROWTH* of the company. A venture's high *GROWTH* leads to a better *RELATIONSHIP* that in turn fosters the venture capitalist's *INVOLVEMENT*. On the contrary, a bad *RELATIONSHIP* caused by bad results could translate into the dismissal of the entrepreneur as the CEO of the company. Finally, *EXIT* is the result of the venture capitalist's *ENDORSEMENT* effect and his direct *INVOLVEMENT* in the company, and of the *GROWTH* of the venture. An *EXIT* event has an effect on the venture capitalist's continuing operations. A known *EXIT* that represents a success story attracts new investors and allows the venture capitalist to create a new fund. Also, success stories from a given venture capitalist attract more entrepreneurs looking forward to being invested by such venture capitalist.

Value-added in Mexico

The venture capitalist in Mexico not only provides equity to the venture but also contributes with non-financial resources to the company, and, like Hsu (2004), concludes that in Mexico the source of capital is as important as the capital itself. From the participants' perspectives, both venture capitalists' and entrepreneurs' perceive that the venture capitalist adds value to the company. To develop the venture, the venture capitalist in Mexico carries out activities similar to those accomplished by his American counterparts. These activities are described at

length in Large & Muegge (2008). However, the study highlights three activities particular to the venture capitalist in Mexico: the outsourcing of venture's non-core functions to the venture capitalist's fund, the focused search for an acquisition exit, and the initial conversion of the venture to a specialized kind of business unit.

The venture capitalist structures his own fund's internal functions, such as accounting, legal, information technology, and human resources, to provides shared services to his portfolio's ventures for a fee. As a result, at least during the early venture's development stages, the venture lacks these functions, and it is not clear when and how the venture recoups these functions to perform as a standalone company. The second difference is that the venture capitalist directs all his efforts to accomplish a trade sale of the venture and not an initial public offering, IPO like his American counterparts. This condition is apparently imposed over the Mexican venture capitalist due to current regulation and the small size of the stock market in Mexico that make very difficult to list a venture capital-backed company. Finally, in his effort to institutionalize the venture, one of the first tasks of the venture capitalist in Mexico is to ensure that the venture business unit is converted into a Sociedad Anónima Promotora de Inversión, S.A.P.I. The venture capitalist can invest his money only in businesses with S.A.P.I. denomination. Considering that this is a new type of business unit in Mexico and that most of the time entrepreneurs are not aware of it and they create their ventures with traditional denominations, the venture capitalist needs to help the entrepreneur to make the venture's conversion in his effort to institutionalize the firm.

Conclusions

The substantive theory that emerged from participants' data argues how the venture capitalist adds value to the venture for building an exit for his investment. To accomplish an exit, the venture capitalist makes use of his experience and knowledge to directly add value to the venture, and of his reputation and business relationships to add value through third parties. The venture capitalist works hand in hand with the entrepreneur to grow the company, make it profitable, sell it, and make a return on the investment. The study also revealed the importance of the relationship between the active investor and the responsible for executing the venture's growth plan to achieve this goal. A good venture capitalist – entrepreneur relationship is essential for the sustained development of the venture and to accomplish the goal of exiting the investment.

This exit goal, however, contrasts with existing views in the literature that relate venture capitalist's value-added with achieving company's milestones (De Clercq et al., 2006), with improving venture performance (Busenitz et al., 2004), with growing the company (Croce, Martí, & Murtinu, 2012), with increasing the financial value of the venture (De Clercq et al., 2006), and with achieving a target company's size in a given time span (Maunula, 2006). Although these goals are somehow related, for example, achieving milestones improve the performance of the company, better company's performance translates into venture growth, growth improves the venture's financial value and is required to achieve a desired venture size, and higher financial value for the venture improves the probability of achieving an exit for the investment, the exit of the investment is necessary to make a return on the venture capitalist's investment. As a result, the ultimate goal of venture capitalist's value-added is to exit his investment.

On the other hand, this particular finding of the venture capitalist's exit goal suggests that attempts to measure venture capitalist's value-added should be related to the exit of the investment. The above supports Large & Muegge (2008) who argue "that future studies should examine 'VC exit success' as a high-impact dependent variable, and place greater emphasis on the measurement of directly observable events for both value-adding inputs and value-added outcomes". The exit becomes a condition to measuring value-added, that is, there is value-added when an exit is accomplished. To measure the value-added by the venture capitalist, one should consider the type of exit and relate it to the expected venture capitalist's contributions. Cumming, Fleming, & Suchard (2005) find that "there are five primary types of venture capital fund exits: initial public offerings (IPOs, or new listings on a stock exchange for sale to the general public), acquisitions (in which the venture capital fund and entrepreneur sell to a larger firm), secondary sales (in which the venture capital fund sells to another firm or another investor, but the entrepreneur does not sell), buybacks (in which the entrepreneur repurchases the interest of the venture capital fund), and write-offs (liquidations)." Once the relationships type of exit – expected venture capitalist's value-added are known, one could measure and improve value-added.

Given the importance of building an exit for the investment, the high-growth entrepreneur should choose a venture capitalist with good reputation and effective business networks to help the venture grow, and with proven success stories about how the venture capitalist multiplied several times his initial investment by achieving an exit. In addition, the entrepreneur not only has to come up with an innovative venture to qualify for venture capital financing, but he also needs to know how to grow a company, manage people, and get results. When the entrepreneur lacks these abilities, the entrepreneur should choose a venture capitalist with proven success in accompanying venture's investments. In any case, entrepreneurs need to be aware and be prepared to work together with the venture capitalist to develop the venture, to be receptive to recommendations from the venture capitalist on how to improve personal and venture performance, and to act accordingly.

Finally, given the larger size of the venture capital industry in Mexico, future research on the value added by the venture capitalist to the venture should move beyond anecdotal stage and dependence on individual testimonies to a general study. This study identified already the significant variables and their relationships of the value-adding process, thus further research should be directed to answer the central question how to measure venture capitalist's value-added. An extension to this study should be related to understanding the relationship between the properties and characteristics of the exits achieved by venture capitalists in Mexico and the value-added to the venture. A growing number of companies with disruptive business models, aggressive government support to the industry, and a growing number of venture capital funds in the country, are big motivations for continuing doing research on venture capital.

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ISSN: 0718-2724. (http://jotmi.org)

Foreign direct investment and technology spillovers in Mexico: 20 years of NAFTA

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Abstract: This article analyses the development of technology capabilities in the manufacturing sector of Mexico during the last two decades. It has been argued that the inclusion of Mexico in the North America Free Trade Agreement (NAFTA) in 1994 would be enough to catch up with Canada and the United States. In this regard, trade liberalisation and foreign direct investment (FDI) would have been two strategic tools to close the technology gap between Mexico and its commercial partners in North America. Yet, after twenty years of NAFTA, it has been demonstrated that many indigenous firms in Mexico must develop an absorptive capacity to benefit from FDI. This paper suggests that the debate on the Asian miracle in the 1990s could be an adequate theoretical framework to discuss technology development and industrialisation in the case of emerging economies. In fact, this debate reveals two alternative approaches to explain the development of technology capabilities: (i) the accumulation view of growth, and (ii) the assimilation view of growth. Therefore, the Asian miracle exemplifies how entrepreneurship, learning and a supporting innovation policy could be an adequate strategy to benefit from FDI and technology spillovers in the case of emerging economies.

Keywords: Foreign direct investment; technology transfer; technology spillovers; trade liberalisation; North America free trade; agreement; Mexico.

Submitted: August 30th 2017 / Approved: September 25th 2017

1. Introduction

Recent events in the world economy should be affecting the international business environment to a more protectionist trade system. In North America, for example, latest political changes in the United States mean the possibility of negatively affecting commercial flows and foreign direct investment (FDI) in the next years. These changes in the commercial policy of the United States are in opposition to the free trade principles of the North America Free Trade Agreement (NAFTA). Particularly, in the case of Mexico, NAFTA has meant the possibility of catching up with its North American partners to access modern technologies and to develop a more competitive economy. However, the results achieved in the North America region are controversial in that there is not convergence between Mexico and other NAFTA countries (Blecker, 2003, 2014; Hartman, 2010; Weisbrot et al., 2014). Indeed, it remains deep differences between Mexico and its North American partners in relation to per capita income, creation of new jobs, long-term increases in productivity, and so forth (Blecker, 2014; Weisbrot et al., 2014).

The rational of FDI in Mexico during the last twenty years has been the belief that it would generate externalities in the form of international technology transfer (Aitken and Harrison, 1999). In this regard, it has been suggested these externalities would be allocated in the form of technology capacity in domestic markets. Typically, technology transfer externalities would derive from firm-specific knowledge of foreign firms given that indigenous firms would be exposed to new products, production, marketing, and technical support (Aitken and Harrison, 1999; Behera, 2015; Erdal and Göçer, 2015). In addition, some scholars have pointed out the importance of foreign firms' nontangible assets as a means of increasing productivity among indigenous firms (Aitken and Harrison, 1999).

From a different perspective, the Economic Commission for Latin America and the Caribbean (ECLAC) has stressed the importance of FDI in Latin American countries during last decades (ECLAC, 2015). Accordingly, ECLAC mentions that FDI in Latin American countries has complemented the resources needed to ensure an adequate rate of economic growth. This report indicates that Brazil and Mexico have been the main countries receiving inward FDI in Latin America during the last decades (ECLAC, 2015). Specifically, in the case of Mexico, Paul Krugman said that even if inward FDI sharply increased in this country since the 1990s, the '*Mexican Miracle*' has disappointed many people given that trade liberalisation has not been enough to achieve a better technological performance in Mexico (Saldaña, 2015). In the same way, Lederman and Maloney (2006) have pointed out that NAFTA has not been enough to close the technology gap between Mexico and its commercial partners in North America. Also, other scholars have suggested that in the case of many emerging economies, there are other important factors needed to successfully acquire and absorb new technologies from abroad (Dahlman, 1994; Hobday, 1995; Kim, 1998; Pack and Nelson, 1999).

However, from a theoretical perspective, two alternative approaches have emerged to explain the effects of FDI in emerging markets (Erdal and Göçer, 2015; Mahmood and Singh, 2003; Storm et al., 2005). The first approach concerns to how R&D carried out in leading countries may affect the productivity of indigenous firms in emerging economies by means of trade, new investments, and technological/geographical proximity (Coe and Helpman, 1995). The second approach considers the association between the presence/intensity of trade liberalisation (imports) and FDI given that this process may increase the productivity of indigenous firms (Aitken and Harrison, 1999; Blomstrom and Kokko, 1998; Gorg and Greenway, 2004; Markusen, 2002). This approach also suggests that to take full advantage of FDI,

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indigenous firms must develop some complementary technological capabilities to successfully adopt new technologies and innovations from abroad (Dahlman et al., 1987; Lall, 1992). It is important to mention that the process of absorbing, adapting, or developing new technologies from further R&D in emerging economies is unique to each country, depending on their level of economic development and degree of modernisation (Gerschenkron, 1962; Prados de la Escosura, 2005).

From an empirical perspective, evidence demonstrates that there is not apparent convergence between technologies developed in newly industrialised countries and technologies developed in industrialised countries (Kim and Lau, 1994). In fact, lessons from newly industrialised countries demonstrate the fallacy of the traditional *laissez-faire* approach on markets (Krugman, 1994). Instead, evidence demonstrates that the growth of newly industrialised economies has been the result of sophisticated industrial and strategic trade policies that have promoted selective protectionism in some industries and firms (Krugman, 1994). In addition, some scholars have suggested the importance of developing an absorptive capacity to benefit from FDI and technology spillovers in the case of emerging economies (Glass and Saggi, 1998). In the case of emerging economies, firm capacity, geographic location and the ownership structure of foreign firms are the most important variables affecting the effectiveness of technology spillovers among indigenous firms in these markets (Behera, 2015; Liang, 2017). Actually it seems that indigenous firms with previous R&D investment and highly educated work force are more likely to effectively profit from technology spillovers spilled out by multinational enterprises (MNEs) (Blalock and Gertler, 2008).

Consequently, this paper aims to get insight on how inward FDI in Mexico have contributed to develop technology capabilities among indigenous firms after its inclusion in NAFTA in 1994. It is argued that Mexico's weak national learning and innovation capacity has been a critical missing complement to trade liberalisation to achieve a higher level of performance among indigenous firms (Lederman and Maloney, 2006). Therefore, the questions conducting this research are as follows: Is there any evidence of technology capacity developments from inward FDI in Mexico after its inclusion in NAFTA in 1994? And, what were the main variables promoting the development of a positive technology capacity effect from inward FDI on the Mexican economy after 1994?

In addition to this introduction, this paper is organised into four sections. Section 2 offers a literature review of the debate on FDI and economic growth and development from the perspectives of the accumulation view of growth and the assimilation view of growth. This section also discusses the main features characterising the process of technology transfer across NAFTA countries. Section 3 discusses an econometric model to test the possibility of finding technology capacity developments in Mexico after 1994. Section 4 analyses the main findings achieved in this research. Finally, Section 5 presents some conclusions.

2. Literature Review

2.1. Foreign direct investment and economic growth

In the decade of the 1990s, the debate on economic growth and development was mainly focused on East Asian countries (Dowling, 1994; Krugman, 1994; Kuznets, 1994). However, in the case of emerging economies, this debate opened up an important discussion on the relation between inward FDI, on the one hand, and economic growth and development, on the other. Typically, the discussion on East Asian countries confronted two alternative theoretical approaches (Mahmood and Singh, 2003): the accumulation view of growth, and the assimilation view of growth. The accumulation view of growth stressed the importance of investing in human and physical capital to increase economic growth (Collins and Bosworth, 1996; Young, 1995), while the assimilation view of growth stressed the importance of innovation, entrepreneurship and learning to improve economic growth (Dahlman, 1994; Hobday, 1995; Kim, 1998; Pack and Nelson, 1999). However, from the perspective of the accumulation view of growth, scholars suggested that high rates of savings and investments should be necessary to enable the use of technologies from abroad (Collins and Bosworth, 1996; Young, 1995). In contrast, from the assimilation view of growth, researchers argued that the critical source of economic growth would depend on high levels of productivity supported by learning, entrepreneurship and innovation when advanced foreign technologies were adopted in developing countries (Dahlman, 1994; Hobday, 1995; Kim, 1998; Pack and Nelson, 1999). Table 1 shows some literature in relation to these approaches.

Table 1. Selected literature on FDI and the accumulation/assimilation view of growth

Author	*Variables*	*Contribution*
Collins and Bosworth (1996)	Physical and human capital	*Accumulation view of growth.* High rates of economic growth by means of sustaining high rates of saving and investment.
Dahlman (1994)	Acquisition of foreign technology, domestic technology effort, and human resource base	*Assimilation view of growth.* Exposure to world competition might be improving productivity and quality and to keep up with new technologies.
Hobday (1995)	Flying geese model	*Assimilation view of growth.* The flying geese model underplays the significance of other economies as a market and as a source of technology and investment, and it must recognise the importance and significance of other factors in host countries (e.g. learning, entrepreneurship and innovation).
Kim (1998)	Tangible capital and labour	*Assimilation view of growth.* Economic growth as the result of the growth of tangible inputs, and not technical progress or the increase in TFP.
Krugman (1994)	Employment, education and physical capital stock, technological knowledge, and TFP	*Accumulation view of growth.* The maintenance of an open trading regime and targeted intervention regime for boosting promising successful sectors to catch up with industrialised countries.
Pack and Nelson (1999)	Several variables characterising both approaches of this debate	*Assimilation view of growth.* Economic growth as the result of major changes in the structure of the economy including shifts in the size of the firms and the sectors of specialisation. Economic growth mainly results from entrepreneurship, innovation, and learning.
Young (1995)	Education and capital investment	*Accumulation view of growth*. The maintenance of an open trading regime and targeted intervention regime for boosting promising successful sectors to catch up with industrialised countries.

Source: Authors' elaboration.

The accumulation view of growth thus suggested that economic expansion in emerging economies would be represented by the sum of two different forces (Krugman, 1994): (i) the growth in inputs (e.g. employment, education, physical capital, and so forth) and (ii) the growth in technology knowledge and management capabilities developments. However, this approach also stressed the importance of increasing the total factor productivity (TFP) to profit from technology advances and maintain a sustained rate of economic growth (Krugman, 1994). Accordingly, in the case of East Asian countries, factor accumulation, education improvements, high rates of investment and intersectoral transfers of labour were key factors to explain the high rates of economic growth during the 1990s (Young, 1995). Also, from this perspective, it has been argued that physical and human capital accumulation have been at the basis of the theoretical explanation on economic growth from the accumulation view in developing economies (Collins and Bosworth, 1996). Accordingly, in the case of emerging economies, the maintenance of an open trading regime to promote higher levels of economic efficiency and a targeting intervention regime to boost promising successful sectors have been two important policies to catch up with industrialised countries (Collins and Bosworth, 1996; Krugman, 1994; Young, 1995). Shortly speaking, some scholars have suggested that the high rates of economic growth observed in many East Asian countries during the 1990s were the result of exhibited range of government strategies that went from extreme *laissez-faire* to extensive intervention in specific sectors (Collins and Bosworth, 1996; Krugman, 1994; Young, 1995). From this perspective, these researchers have found that productivity gains, not capital formation, was the fundamental explanation on economic growth in East Asian countries during the 1990s, and therefore TFP has unexpectedly played a small role to explain economic growth in these countries (Collins and Bosworth, 1996; Krugman, 1994; Young, 1995).

On the other hand, the assimilation view of growth argued that economic growth in East Asian countries during the 1990s was accompanied by other major changes in the structure of these economies, namely firm size and sector specialisation (Pack and Nelson, 1999). These changes allowed a superior productive assimilation of capital flows through mastering new technologies adopted from advanced industrialised countries, mainly developing entrepreneurship, innovation and learning capabilities (not only investing in human and physical capital) (Nelson and Peck, 1999; Dahlman, 1994; Hobday, 1995; Kim, 1998). From this perspective, the assimilation of increasingly modern technologies and the possibility of other important changes in the industrial structure of these economies gave rise to a process of learning, innovation and entrepreneurial efforts that were critical to get a comprehensive explanation on economic growth in East Asian countries (Pack and Nelson, 1999). In fact, the development of new technologies in new sectors requires the expansion of a new set of entrepreneurial skills and firm management capabilities to improve the capacity to compete in new markets (Pack and Nelson, 1999). Accordingly, the policy environment in East Asian countries was critical to firms' success as a third factor to the conventional production function, expanding educational attainments by well-trained managers, engineers and applied scientists capable to provide a competitive advantage to identify new opportunities and an effective learning process (Pack and Nelson, 1999). From this perspective, the possibility of developing a sustained competitive advantage among

indigenous firms imply an effective learning process to master new technologies from industrialised countries (López-Rodríguez and García-Rodríguez, 2005; Rodríguez et al., 2015).

In the case of NAFTA, it was said that the inclusion of Mexico in this agreement would enhance its economic performance through acquiring new technologies from abroad. However, technology transfer has been unbalanced between Mexico and its commercial partners in North America (Lederman and Maloney, 2006; Weisbort et al., 2014). Even if some positive results have been achieved in the case of Mexico, trade liberalisation and other economic policies implemented in this country during the last twenty years have not been enough to guarantee higher levels of economic performance (Rodríguez and Gómez, 2011; Weisbort et al., 2014). Actually trade liberalisation has been helpful but not enough to catch up with the level of technology progress in Canada and the United States (Lederman and Maloney, 2006). In fact, Mexican firms need to develop an absorptive capacity to successfully adopt new technologies from abroad. In this sense, absorptive capacity is a function of the level and rate of change of R&D developed by indigenous firms (Cohen and Levinthal, 1989; Lederman and Maloney, 2006). In short, trade liberalisation and FDI would be an adequate explanation for TFP in many developing countries (Lederman and Maloney, 2006). Yet, some researchers have suggested that trade liberalisation and FDI, on the one hand, and improvements in the absorptive capacity and other major changes in the industrial structure to support learning, innovation and entrepreneurial efforts, on the other, have been critical to effectively achieve higher levels of economic growth and development in many emerging economies (Pack and Nelson, 1999).

2.2. Foreign direct investment and technological spillovers

The international economics theory explains how the availability of raw materials, tariff and non-tariff barriers, low wages, risk diversification, transportation costs, and fiscal incentives may attract FDI from other countries (Appleyard and Field, 2013; Krugman et al., 2014). For example, raw materials availability may positively impact FDI given that MNEs take advantage from low-priced resources to reduce their production costs. The presence of tariffs and non-tariff barriers may also have a positive impact on FDI in that MNEs are advantageous to operate in protected local markets. In the same way, low wages may positively influence MNEs' investment decisions when they are labour-intensive producers. In addition, MNEs decide to invest in foreign markets for strategic reasons to protect their market shares. Risk diversification drives firms' decisions to place certain assets of their investments in other markets as a means of protection. Yet, the presence of transportation costs may impact firm's investment decisions given that FDI tends to replace exports as costs of transportation get higher. Finally, fiscal incentives granted by governments in some countries can produce an advantage to attract FDI inflows.

At a different level of analysis, some researchers have suggested that FDI should not be seen only as a transfer of capital to a host country, but also as a combination of capital, business organisation and new technology transfer (Dussel et al., 2007; Heijs, 2006). Indeed, the effects generated by FDI inflows on the industrial structure of a host country could be of two types (Olechko, 2004). First, there is direct effects from FDI where foreign investors do not acquire all the benefits from the efficiency generated by foreign investments (Heijs, 2006; Olechko, 2004). Instead, direct effects imply the possibility of achieving some gains from inward FDI of a different type, such as higher wages for local workers, lower prices for local consumers, and tax revenues for local governments (Olechko, 2004). Accordingly, direct effects basically refer to the fundamental role played by FDI in the process of economic development that allows achieving higher levels of modernisation in a specific productive system (Heijs, 2006). However, in the case of Mexico, some researchers have suggested that technology spillovers from FDI have contributed to improve labour productivity, economic growth, firms' competitiveness, and so forth (Rivas-Aceves and Puebla-Méndez, 2016). Moreover, modernisation of the existing production capacity in emerging economies could be achieved through mergers and acquisitions induced by FDI, but also by the introduction of new forms of managing and marketing in organisations (Heijs, 2006). Therefore, the introduction of innovations resulting from direct effects of FDI in emerging economies will have a positive effect on markets through developing new sectors or revitalising other existing sectors (Heijs, 2006).

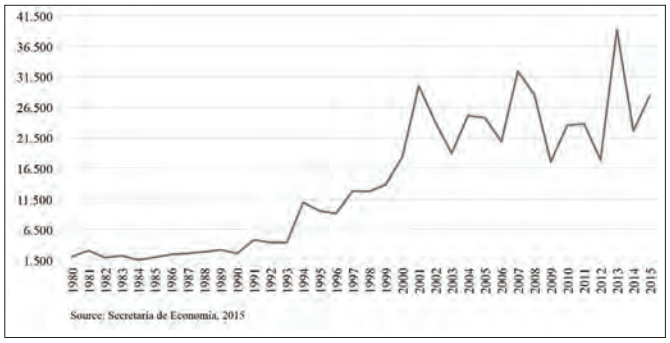
Second, there are other indirect effects generated in the form of technology spillovers (Olechko, 2004). Indirect effects from inward FDI are based on the diffusion of knowledge and technologies among indigenous firms in the from technology spillovers, concerning to the possibility of achieving some benefits by means of technology transfer, production chains, training of human resources, and local business development (Elías et al., 2006). Indirect effects and externalities from FDI in host countries are delivered in the form of new knowledge and innovation diffusion, including technical progress, management and development of organisational skills (e.g. technical, productive and commercial), as well as human capital and innovation capacity improvements (Elías et al., 2006). In this regard, there are two important explanations on the existence of technology externalities (Heijs, 2006). On the one hand, foreign subsidiaries entering into local markets may contribute to explain their expansion through developing non-existing assets and innovations (Heijs, 2006). On the other, inward FDI forces indigenous firms to adjust their strategic decisions to protect their market shares and profit margins (Heijs, 2006). Nevertheless, technological capabilities may contribute to acquire the skills needed to develop a path of sustained growth, mainly knowledge and skills needed to obtain, use, absorb, adapt, improve and generate new technologies (Bell and Pavitt, 1993; Lall, 1992). In short, the presence and intensity of technology spillovers depend on firms' absorptive capacity, as well as the level of economic development of the host country that allows absorbing, adapting, and improving technologies from abroad (Brown and Dominguez, 2004). Thus, the complexity of a production process, the technology used by foreign companies, the degree of economic development, and other domestic firms' technological capabilities are essential to develop an absorptive capacity (Vera-Cruz and Dutrénit, 2007).

Finally, the level and similarity of technological capabilities between indigenous firms and foreign firms become a basic condition to establish appropriate links to developing a reciprocal learning process (Narula, 2004). In this regard, competitive firms with superior absorptive capacity will take advantage from technological spillovers (Narula, 2004). Accordingly, when domestic firms are technologically far from foreign firms, they would be less capable of learning from new technologies and knowledge (Javorcik, 2002, 2004). Actually the process of technology spillovers requires an effective and comprehensive policy to provide a supporting environment for investments and to create adequate institutional and human capabilities (OECD, 2008). Evidence demonstrates that in the case of Mexico, spillover effects have only occurred in some sectors with high levels of technological capabilities developments (Blomstrom and Pearsson, 1983; Brown and Dominguez, 2004).

2.3 Foreign Direct Investment in Mexico

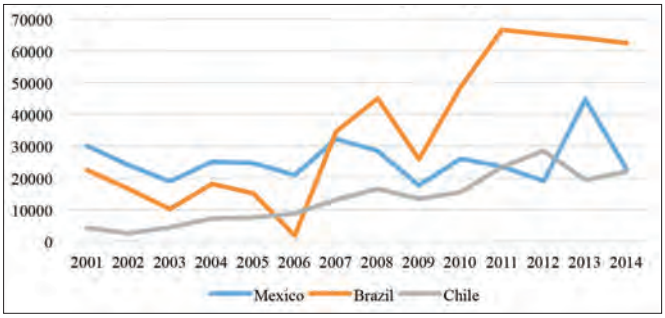
The *Foreign Direct Investment in Latin America and the Caribbean 2015* report released by the Economic Commission for Latin America and the Caribbean (ECLAC, 2015) positioned Mexico as the second largest recipient of inward FDI in Latino America. Even if FDI in Latin America countries has been significantly important, it only represented a small fraction of the GDP in this region during last years. In the case of Mexico, for example, the manufacturing sector accounted 70% of the total inward FDI (ECLAC, 2015). However, in this country, the total amount of net capital inflows and reinvested profits of transnational corporations have shown a growing trend since the 1990's (Figure 1) (ECLAC, 2015).

Figure 1. Mexico Inward FDI, 1980 - 2015



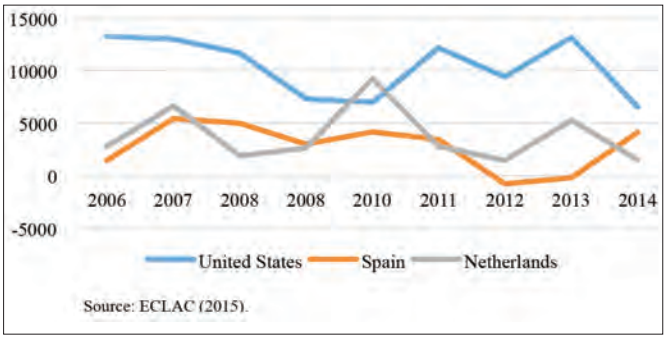
In the case of Latin America countries, Brazil, Chile and Mexico have been the most important recipients of inward FDI in the last decades (Figure 2). Specifically, in the case of Mexico, the *Foreign Direct Investment in Latin America and the Caribbean 2015* report mentions that FDI inflows in this country have been more important during the lately past years than in the previous decade of the 1990s (ECLAC, 2015). However, some stylised facts characterising FDI inflows in Mexico can be established (ECLAC, 2015). First, Mexico was one of the most important recipients of FDI inflows in this region during the last years. Second, FDI inflows in this country accounted more than $40,000 dollars in 2013, and more than $25,000 dollars in 2014. Third, the automotive industry in Mexico was the largest FDI recipient in 2014, absorbing $4,308 billion dollars of the total investment in this country ($12.87 billion dollars). Fourth, financial services in Mexico received approximately one third of total FDI inflows in 2014 being the dominant sector in this country in relation to the total investment received from abroad. Finally, financial services represent 25% of the total FDI in this country (ECLAC, 2015). In short, data of FDI inflows in Mexico shows the importance of foreign investment in the automotive, financial services and natural resources sectors (ECLAC, 2015).

Figure 2. Latin America Inward FDI by Country, 2001 - 2014



On the other hand, evidence demonstrates that the United States remains the largest foreign investor in Mexico, accounting more than 30% of the total FDI inflows in this country during the last years. Actually the United States invested in Mexico more than in the previous decade and the two-year average inward of FDI ever recorded in this country (Figure 3). It is important to mention that Spain, the Netherlands, Belgium, Canada, Germany and Japan are also important foreign investors in Mexico (ECLAC, 2015).

Figure 3. Mexico Inward FDI by Country of Origin, 2006 - 2014



The importance of FDI in emerging economies should continue spilling over indigenous firms, bringing technology advancements into firms. In the case of Mexico, foreign investment mostly concerns to greenfield projects which create or expand the production capacity. In this case, FDI inflows generate different impacts on the economy. However, in the case of this country, not all FDI is invested in high-tech manufacturing sectors, limiting the potential of transferring knowledge for improving the local technology capacity.

According to the ECLAC report (ECLAC, 2015), the main trends of FDI in Latin America countries will remain stable in the next years. Yet, the political facts recently observed in the United States may change these trends in the case of Latin America countries in general,

and particularly in the case of Mexico. Importantly, outflow FDI from emerging countries has been recognised as an important source of investments in other developing and developed economies during the last years. For instance, twenty of the largest mergers and acquisitions carried out by Latin America firms originated in Mexico (ECLAC, 2015).

From a different perspective, scholars have analysed the possibility of finding technology spillovers from inward FDI in the case of emerging economies. The case of Mexico has been studied by many scholars (Jordan, 2011; Lederman and Maloney, 2006; Rodríguez-Pose and Villarreal-Peralta, 2015; Romo, 2005). Jordan (2011), for example, finds substantial evidence of FDI impact on higher levels of local dynamics markets, depending on the level of the absorptive capacity of suppliers, the size of the technology gap between producer and suppliers, and the provision of producer firms. Lederman and Maloney (2006) mention that trade liberalisation and NAFTA have been helpful, but not enough to help Mexico catching up with the level of technological progress in the United States and Canada. Rodríguez-Pose and Villarreal-Peralta (2015) analyse the possibility of finding technological spillovers across 32 states of Mexico, stressing the importance of the relationship between regional economic growth and R&D investment in areas with favourable social conditions for innovation. Finally, Romo (2005) analyses FDI as an engine to boost economic development. In fact, this author pointes out the importance of inward FDI in the case of emerging economies as a mechanism to acquire new technologies from abroad.

3. The Model

Data from *Encuesta Nacional de Empleo, Salarios, Tecnología y Capacitación en el Sector Manufacturero* (National Survey of Employment, Salaries, Technology and Training in the Manufacturing Sector, ENESTYC) and *Encuesta sobre Investigación y Desarrollo de Tecnología* (Survey of Investment and Technology Development, ESIDET) released by *Instituto Nacional de Estadística y Geografía* (National Institute for Statistics and Geography, INEGI) are used to test the hypotheses in this research. The dependent variable, Technology Capacity Index (TCI), in Model 1 and Model 2 aims to capture the possibility of finding evidence of technology capacity developments from inward FDI in Mexico. However, other variables are also included in these models to test evidence of technology capacity developments in the case of the Mexican manufacturing sector.

The independent variables in Model 1 are Foreign Direct Investment (FDI), Exports (XS), Large and Medium Size Firms (LMF), Small Size Firms (SF), Age of Firms with 15 years or less in Markets (E1), and Age of Firms between 15 and 25 Years in Markets (E2). On the other hand, the independent variables in Model 2 are Foreign Direct Investment (FDI), Exports (XS), Innovation (INN), Research and Development (R&D), and Introduction of New Processes (PR). Accordingly, seven hypotheses were established in this research to test the presence of technology capacity developments in Mexico. Hypothesis 1 and Hypothesis 2 aim to capture the importance of FDI to develop technology capabilities in the manufacturing sector of Mexico (Mahmood and Singh, 2003). However, this process is developed through the association between the presence/intensity of FDI and trade liberalisation, on the one hand, and productivity of receiving firms/importing firms, on the other (Aitken and Harrison, 1999; Blomström and Kokko, 1998; Blomström and Persson, 1983; Gorg and Greenway, 2004; Markusen, 2002). From the same theoretical perspective, other studies identify the link between innovation and exports to explain the development of firms' competitiveness in the case of emerging economies (Enjolras et al., 2016). Therefore, in the case of Mexico, the following two hypotheses can be established in the case of Mexico:

Hypothesis 1: Increases in FDI inflows may positively explain the presence of technology capabilities developments in Mexico ($\beta_1>0$).

Hypothesis 2: The diffusion of new technologies that increases exports competitiveness may positively explain the presence of technology capabilities developments in Mexico ($\beta_2>0$).

From the perspective of the assimilation view of growth, however, major changes in the structure of industries in emerging economies should facilitate the assimilation of new technologies from abroad. In this case, the main variables allowing these changes are firm size and sector specialisation (Pack and Nelson, 1999). Indeed, this idea suggests that firm evolution from a small size to a large size would be an indicator of this kind of changes. This argument is Schumpeterian in nature given that Schumpeter's idea on innovation is associated to a two-step evolving process (Fontana et al., 2012; Gómez and Rodríguez, 2012; Malerba, 2005): Schumpeter Mark I pattern (1934) and Schumpeter Mark II pattern (1942). Schumpeter Mark I considers that small firms are more innovative than large firms. In fact, Schumpeter Mark I industries are characterised by a turbulent environment with relatively low entry barriers (Fontana et al., 2012). Accordingly, firms in Schumpeter Mark I are more flexible to adapt to changing turbulent environments through a 'creative destruction' process with successful innovating entrants that replace incumbent firms (Fontana et al., 2012; Malerba, 2005; Narula, 2004). By contrast, Schumpeter Mark II industries suggests a stable environment with relatively high entry barriers in which innovations are generated and developed by large established firms (Fontana et al., 2012; Narula, 2004). In this sense, an oligopolistic market structure with large established firms and important R&D activity characterises Schumpeter Mark II as the main source of innovation and technology change. In Schumpeter Mark II industry technological competition assumes the form of 'creative accumulation' with incumbent firms introducing innovation developments (Fontana et al., 2012; Malerba, 2005). As a result, two other hypotheses can be established in the case of Mexico:

Hypothesis 3a: The existence of large and medium size firms may positively explain the presence of technology capabilities developments in Mexico ($\beta_3>0$).

Hypothesis 3b: The existence of small size firms may positively (or not) explain the presence of technology capabilities developments in Mexico ($\beta_4>0?$).

In this way, it is expected that younger firms will be more innovative that older firms. The fact is that younger firms are more disposal to adapt or create new markets by developing innovations. Nevertheless, some scholars have suggested that older firms are more innovative than younger firms in that older firms are associated to resources availability for R&D (Savino and Petruzzelli, 2012; Withers et al., 2011; Noordin and Mohtar, 2014). However, there is not strong evidence that support this proposition (Noordin and Mohtar, 2014). Therefore, the following two hypotheses can be stated in the case of Mexico:

Hypothesis 4a: Firms with 15 years or less in markets may positively explain the presence of technology capabilities developments in Mexico ($\beta_5>0$).

Hypothesis 4b: Firms with more than 15 years in markets may negatively explain the presence of technology capabilities developments in Mexico ($\beta_6<0$).

In addition, data from the Survey of Investment and Technology Development (ESIDET) allows testing other three hypotheses. Model 2 uses data on innovation developments, R&D spending, and introduction of new processes to test these hypotheses. However, these variables may confirm the presence of technology capacity developments that may be spilling over the rest of the economy. Indeed, Model 2 tests the presence of technology capabilities in relation to the efforts carried out by firms to develop innovations, and thus the following three hypotheses can be established in the case of Mexico:

Hypothesis 5: The development of innovations may positively explain the presence of technology capabilities developments in Mexico ($\beta_7>0$).

Hypothesis 6: Firm spending in R&D may positively explain the presence of technology capabilities developments in Mexico ($\beta_8>0$).

Hypothesis 7: The introduction of new processes into firms' production systems may positively explain the presence of technology capabilities developments in Mexico ($\beta_9>0$).

Ordinary least squares (OLS) are used to compute Model 1 and Model 2. Specifically, pooled OLS are applied to test changes over time between explanatory and dependent variables. The matrix approach used in this research allows establishing the estimation procedure as follows:

$$Y_i = Z_i\beta + \varepsilon_i, \text{ where } Z_i = [X_{it}K_{it}]$$

Y_i in this equation is a vector of the dependent variable, Z_i is a matrix of explanatory variables, and ε_i is a vector of errors in the model. The estimators in this equation are estimated applying pooled OLS methods. Therefore, the estimators can be represented as follows:

$$\hat{\beta}_{MCA} = (Z_i'Z_i)^{-1}(Z_i'Y_i)$$

Accordingly, it would be possible to establish a more precisely relationship between the relations evaluated in these models when changes in the variables result from time passing (Ezequiel, 2013; Humérez, 2013). The objective is thus to test the possibility of finding a relationship between inward FDI and technology capacity developments in the manufacturing sector of Mexico, as well as other variables included in the models. The models estimated in this research are cross-sectional with $i = 9$ sectors, and $t = 1992, 1995, 1999, 2001, 2005$ and 2012. In this regard, Model 1 is estimated as follows:

$$TCI_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 XS_{it} + \beta_3 LMF_{it} + \beta_4 SF_{it} + \beta_5 E1_{it} + \beta_6 E2_{it} + e_{it}$$

Table 2 shows the variables of Model 1. The dependent variable in this model, Technology Capacity Index (TCI), depends on the independent variables Foreign Direct Investment (FDI), Exports (XS), number of Large and Medium Size Firms (LMF), number of Small Firms (SF), number of firms with 15 years or less in the market (E1), and number of firms between 15 and 25 years in the market (E2).

Table 2. Model 1: variables description

Name	Variable	Description
Technology Capacity Index	TCI	Logarithm of the technology capacity index.
Foreign Direct Investment	FDI	Percentage of foreign capital to total capital of the firm.
Exports	XS	Logarithm of foreign sales.
Large and Medium Size Firms	LMF	Logarithm of the number of large and medium size firms.
Small Size Firms	SF	Logarithm of the number small firms.
Age of Firms with 15 Years or Less in Markets	E1	Logarithm of the number of firms that have 15 years or less in the market.
Age of Firms between 15 and 25 Years in Markets	E2	Logarithm of the number of firms that have between 15 and 25 years in the market.

On the other hand, Table 3 shows how the dependent variable, Technology Capacity Index (TCI), is computed. Indeed, the Technology Capacity Index (TCI) comprises three different set of variables drawn from the ENESTYC: (i) learning and investment, (ii) production, and (iii) linkage with other firms. In this case, dimensions, units and values are defined for each set of variables (Table 3).

Table 3. Model 1: Technology Capacity Index (TCI) in the Mexican manufacturing sector (ENESTYC)

Set of Variables	Variable Dimensions	Unit	Value
Learning and Investment	Transfer of technology from the parent firm. Acquisition of new technologies from other firms. Acquisition of blueprints and advice from other sources. Resources invested for R&D. Activity sub-sector: big, medium, small, and micro.	Percentage	0 = None 1 = 0.1 to 2.0 2 = 2.0 to 3.9 3 = 4.0 or more
Production	Number of units with new machinery and equipment: manual equipment, automatic equipment, machinery, machinery and tools with numeric control, computer machinery and tools, and robots. R&D investment: new products design, improvement of production process and product quality, design and improvement of machinery and equipment.	Percentage	0 = None 1 = 0.1 to 2.0 2 = 2.0 to 3.9 3 = 4.0 or more
Linking with other Firms	Training for workers by activity sector: big, medium, small, and micro.	Percentage	0 = None 1 = 0.1 to 2.0 2 = 2.0 to 3.9 3 = 4.0 or more

Source: Adapted from Brown and Domínguez (2004), and Pérez and Pérez (2009).

It is important to mention that ENESTYC is not applied since 2012. In its place, ESIDET was applied in 2012. However, both surveys allow getting data on technology and innovation activity in the manufacturing sector of Mexico. Nevertheless, the change in the source of information implies the need to estimate a new model:

$$TCI_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 XS_{it} + \beta_7 INN_{it} + \beta_8 R\&D_{it} + \beta_9 PR_{it} + e_{it}$$

In Model 2, variables were defined searching to reflect the level of technological developments in the manufacturing sector of Mexico accordingly to the taxonomy proposed by Lall (1992), Brown and Domínguez (2004), Pérez and Pérez (2009), and others.

Table 4. Model 2: variables description

Name	Variable	Description
Technology Capacity Index	TCI	Logarithm of the technology capacity index.
Foreign Direct Investment	FDI	Percentage of foreign capital to total capital of the firm.
Exports	XS	Logarithm of foreign sales.
Innovation	INN	Number of firms developing innovations.
Research and Development	R&D	Number of firms investing in research and development.
Introduction of New Processes	PR	Number of firms introducing new processes into their production systems.

As in Model 1, the Technology Capacity Index (TCI) in Model 2 is considered as the dependent variable (Table 3), and then FDI, Exports (XS), Innovation (INN), Research and Development (R&D) and Introduction of New Processes (PR) as the independent variables (Table 4).

Table 5. Model 2: Technology Capacity Index (TCI) in the Mexican manufacturing sector (ESIDET)

Set of Variables	Variable Dimensions	Unit	Value
Learning and Investment	Extramural R&D investment in technology development. Intramural R&D investment in technology development. Intramural R&D investment in new products development. Firms' spending in human resources training (higher education graduate programs). Firms' spending in human resources training (R&D technology developments). Spending in technology services. Number of firms acquiring new technologies for improving their production capacity and/or acquiring new machinery and equipment for improving their production processes and/or absorbing new technologies and/or adapting new technologies for improving their levels of efficiency and/or developing their own technologies and/or patenting new products or technologies and/or patenting new products and technologies for their own use and/or patenting new technologies for licensing.	Percentage	0 = None 1 = 1 to 10 2 = 10 to 30 3 = 30 or more
Production	Firms' researchers and technologists developing intramural R&D projects. Firms' technicians developing intramural R&D projects. Firms' management personal supporting intramural R&D projects. Firms' management personal supporting extramural R&D projects. Firms' personal supporting human resources training at higher education level. Firms' personal trained for specialised technical tasks.	Percentage	0 = None 1 = 1 to 10 2 = 10 to 30 3 = 30 or more

Source: Adapted from Brown and Domínguez (2004), and Pérez and Pérez (2009).

In the same way, as in Model 1, Table 5 shows how the dependent variable, Technology Capacity Index (TCI), is computed following the methodology proposed by Brown and Domínguez (2004), Pérez and Pérez (2009), and others.

Results

The research methods used in these models are like those developed by Brown and Domínguez (2004) and Pérez and Pérez (2009), among others. Yet, some other studies analyse the case of Mexico, such as Armas (2017), Brown and Domínguez (2004), Brown and Guzmán (2014), Jordan (2011), Pérez and Pérez (2009), Rodríguez and Gómez (2011), Rodríguez-Pose and Villarreal-Peralta (2015), and Romo (2005). However, in this research, the TCI of the Mexican manufacturing sector was computed by means of using the taxonomy proposed by Lall (1992), and Bell and Pavitt (1993). Two panel data regression models were estimated using cross-sectional and time series data (i = 9 and t = 1992, 1995, 1999, 2001, 2005, 2012). The models were tested for normality and homoscedasticity (White Test) to find out whether errors were homoscedastic and normally distributed (White, 1980). The analysis discussed in this section allows the possibility of finding technology capacity developments within the Mexican manufacturing sector.

Model 1 tests Hypotheses 1 – 4. The values of Adjusted R^2 = 0.8990 and F-statistic = 66.31 validate the results achieved in this model (Table 6). As predicted by Hypothesis 1, the variable FDI is positive and significant. Importantly, this unexpected result achieved in Model 1 suggests that FDI in Mexico have been less important to explain TCI developments in this country. In the same way, FDI in Model 2 is positive and no significant, and thus the null hypothesis ($\beta_1 = 0$) cannot be rejected (t-statistic = 1.26). This finding supports the idea that FDI and trade liberalisation in Mexico have not been enough to catch up with its North America commercial partners (Lederman and Maloney, 2006). In fact, this result also supports the idea that the assimilation view of growth should be an adequate theoretical explanation to explain this possibility only if FDI and trade liberalisation are accompanied by learning, entrepreneurship and innovation developments (Dahlman, 1994; Hobday, 1995; Kim, 1998; Pack and Nelson, 1999). In this regard, further results achieved in Model 2 will demonstrate the importance of innovation developments, R&D spending, and the process of incorporating new process by indigenous firms to develop higher levels of technology capacity in the manufacturing sector of Mexico.

Hypothesis 2 in Model 1 (and Model 2) suggests that the diffusion of new technologies increases exports competitiveness and thus the development of technology capabilities in the manufacturing sector of Mexico (Enjolras et al., 2016; Erdal and Göçer, 2015). In this case, the variable XS is positive and significant, and thus the null hypothesis ($\beta_2 = 0$) can be rejected (t-statistic = 5.91). In Model 2, the null hypothesis is rejected (t-statistic = 2.95) in favour of the alternative hypothesis that explain the development of technology capabilities in this country when indigenous firms can learn and get new knowledge in foreign markets to locally accumulate technology capabilities becoming more competitive in international markets.

Table 6. Regression results: Technology Capacity Index (TCI) in the manufacturing sector of Mexico

Variable	Model 1 (Dependent Variable: TCI)			Model 2 (Dependent Variable: TCI)		
	Coefficient (t-statistic)	*Standard Error*	*Prob*	*Coefficient (t-statistic)*	*Standard Error*	*Prob*
C	-1.727931 (-13.80)	0.125191	0.0000	-0.954973 (-1.54)	0.617866	0.1396
FDI	0.002213 (1.86)	0.001186	0.0699	0.001404 (1.26)	0.001109	0.2218
XS	0.053614 (5.91)	0.009059	0.0000	0.106889 (2.95)	0.036182	0.0085
LMF	0.232388 (5.34)	0.043475	0.0000			
SF	-0.150162 (-3.11)	0.048258	0.0035			
E1	0.123797 (4.73)	0.026146	0.0000			
E2	-0.030873 (-1.46)	0.021060	0.1509			
INN				0.001173 (2.93)	0.000399	0.0088
R&D				0.009460 (2.69)	0.003510	0.0148
PR				0.016987 (2.52)	0.006733	0.0213
Adjusted R^2	0.8990			0.7426		
F-statistic	66.31			14.27		

Hypothesis 3a and Hypothesis 3b test the Schumpeterian idea on the nature of innovation as a two-step evolving process (Schumpeter, 1934, 1942). The *t*-statistic in the case of LMF (*t*-statistic = 5.34) allows rejecting the null hypothesis ($\beta_3=0$) in favour of the alternative hypothesis, and suggesting that LMF is significant to explain the development of technology capabilities in the manufacturing sector of Mexico. In the same way, the *t*-statistic in the case of SF (*t*-statistic = -3.11) allows rejecting the null hypothesis ($\beta_4=0$) in favour of the alternative hypothesis that explain SF significant to the development of technology capabilities in the Mexican manufacturing sector. Nevertheless, a negative sign is obtained in the case of the variable SF in contrast to the case of the variable LMF. This finding suggests that small size firms in the manufacturing sector of Mexico are less disposal to innovate in relation to large and medium size firms, hypothesis already suggested by Schumpeter (Mark II characterised by stable oligopolistic markets and high entry barriers) (Schumpeter, 1942). Therefore, in the case of LMF, firm size has a positive impact on TCI through the development of absorptive capabilities and R&D spending to advance new technologies. Importantly, in the case of Mexico, the negative sign in the case of variable SF may suggest that small size firms are less capable of developing innovations, and thus they only imitate technology developments carried out by large and medium size firms.

Hypothesis 4a and Hypothesis 4b aims to capture the idea that older firms contribute more to develop technology capabilities. The variable E1 is positive and significant and thus the null hypothesis ($\beta_5=0$) can be rejected (*t*-statistic = 4.73). Nevertheless, the variable E2 is negative and no significant, and thus the null hypothesis ($\beta_6=0$) cannot be rejected (*t*-statistic = -1.46). This finding is against the expected results suggesting that mature firms would be more innovative, and thus they contribute more to develop technology capabilities.

On the other hand, Hypotheses 5 – 7 were tested in Model 2. The values of Adjusted R^2 = 0.7426 and *F*-statistic = 14.27 validate the results achieved in this model (Table 6). However, the results achieved in Model 2 are not conclusive. As already mentioned in Model 1, the variable XS shows a positive sign suggesting that trade liberalisation positively impact the development of technology capacity (TCI) through competition given that this effect improves firms' absorptive capacity for acquiring new technologies from abroad (Enjolras et al., 2016; Erdal and Göçer, 2015). As expected, Hypothesis 5 aims to capture the idea that innovation developments contribute to explain technology advances in the manufacturing sector of Mexico. In Model 2, the variable (INN) shows a positive sign suggesting that the process of innovation developments improve firms'

absorptive capabilities, and thus the null hypothesis ($\beta_7=0$) can be rejected (t-statistic = 2.93) in favour of the alternative hypothesis that explain INN as a source of technology capabilities developments in the Mexican manufacturing sector.

Hypothesis 6, the number of firms developing R&D projects, is positive and significant (t-statistic = 2.69) in relation to the dependent variable Technology Capacity Index (TCI). This result allows rejecting the null hypothesis ($\beta_8=0$) in favour of the alternative hypothesis. Finally, Hypothesis 7, the number of firms introducing new processes into their production systems (PR) shows a positive and significant value (t-statistic = 2.52) in relation to the dependent variable TCI, suggesting that firms generate new knowledge when applying new process into their production systems.

Conclusions

The literature on the development of technology capacity, technology spillovers, and inward FDI has traditionally been focused on the importance of technology transfer as a mechanism to catch up and develop a more competitive economy. In the case of Mexico, these analyses aim to identify the existence of technology spillovers from FDI to improve economic performance of national industries by means of using technologies and processes from abroad. It is argued that the presence of FDI has not been enough to close the technology gap between Mexico and other North American countries (Lederman and Maloney, 2006). Even if the results achieved in this research demonstrate the importance of FDI and the development of technology capabilities from multinational corporations, these results also demonstrate that technology spillovers have not spilled over the rest of the manufacturing sector in Mexico. Indeed, FDI in this country has only contributed to develop technological capabilities in sectors where multinational companies are established (e.g. highly specialised and knowledge-based industries). From this perspective, NAFTA has not generated the results expected in Mexico. Even more NAFTA has deepened the technological gap between Mexico and its commercial partners in North America.

On the other hand, the results achieved in this research support the idea that the assimilation view of growth is an adequate theoretical explanation to understand the low level of performance in the Mexican economy during the last years. In this sense, evidence suggests that the presence of FDI and MNEs in Mexico is not accompanied by innovation, entrepreneurship and learning developments. Moreover, these results also suggest that FDI in Mexico is only positively related to training and collaboration effects. Therefore, policy implications from this research suggest the importance of developing an absorptive capacity among indigenous firms in Mexico to successfully assimilate external knowledge and technologies from abroad.

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ISSN: 0718-2724. (http://jotmi.org)

Cooperation for innovation in developing countries and its effects: evidence from Ecuador

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Abstract: This paper evaluates the impact of the most common innovation linkages by type of innovation activity on firms' innovation inputs and outputs. In order to estimate the casual effects, we employ Inverse Probability Weighting, while focusing on exclusive cooperative agreements to prevent our results from being affected by the presence of additional relationships in other activities or with other types of partners. Results indicate that cooperation in non-R&D innovation activities positively affects the introduction of new-to-the-firm product, marketing and organizational innovations, while cooperation in both R&D and non-R&D activities also affects R&D intensity and new-to-the-market product innovation. Furthermore, firms that cooperate exclusively in obtaining information, which is mainly carried out with suppliers and customers, are more likely to introduce new-to-the-firm product and organizational innovations.

Keywords: non-R&D cooperation; technological capabilities; impact assessment.

Abstract: This paper evaluates the impact of the most common innovation linkages by type of innovation activity on firms' innovation inputs and outputs. In order to estimate the casual effects, we employ Inverse Probability Weighting, while focusing on exclusive cooperative agreements to prevent our results from being affected by the presence of additional relationships in other activities or with other types of partners. Results indicate that cooperation in non-R&D innovation activities positively affects the introduction of new-to-the-firm product, marketing and organizational innovations, while cooperation in both R&D and non-R&D activities also affects R&D intensity and new-to-the-market product innovation. Furthermore, firms that cooperate exclusively in obtaining information, which is mainly carried out with suppliers and customers, are more likely to introduce new-to-the-firm product and organizational innovations.

Keywords: non-R&D cooperation; technological capabilities; impact assessment.

Submitted: May 16th 2017 / Approved: September 22nd 2017

1. Introduction

Empirical studies on networks of innovators focus on the effects of cooperation in R&D activities (Sánchez-González, 2014; Fernández-Sastre, 2015). Nonetheless, if one aims at analyzing the effects of cooperation in less-developed countries, cooperative agreements in non-R&D innovation activities should also be considered, as in these contexts innovation is mostly related to the absorption of technology and competence building rather than to science-based R&D (Chaminade et al., 2010).

Although there are studies assessing the effects of R&D cooperation in developing countries (Temel et al., 2013; Sousa et al., 2015), there is no evidence relating to the impact of cooperation in non-R&D innovation activities, because innovation surveys just provide information on R&D cooperation. In this regard, the Ecuadorian Survey of Innovation 2013 (ENAI) is a notable exception as it also distinguishes between cooperation in the following innovation activities: engineering and design, training, technical assistance, information and product testing.

Drawing on data from the ENAI 2013, this paper establishes the most common innovation activities in which Ecuadorian firms cooperate in order to estimate their effects on firms' innovation inputs and outputs. The remainder of this paper is organized as follows. Section 2 reviews the literature background for our analysis. Section 3 proceeds by describing the data and the variables. Section 4 explains the methodology. Section 5 discusses the implications of the empirical results. Finally, we conclude in Section 6.

2. Literature review

Firms differ in their technical skills and in the way they master new technologies and improve upon them (Lall, 1992). As a result they employ different learning mechanisms to acquire knowledge depending on the level of the technological capabilities they have accumulated (Figueiredo, 2001; Divella, 2017).

In the case of developing countries, most firms are still not prepared to innovate and they coexist with other firms that have developed more successful capabilities (Molina-Domene and Pietrobelli, 2012). Therefore, in these countries, most cooperative relationships are often not associated with R&D but have the objectives of obtaining information and carrying out training activities (Anlló and Suárez, 2008). These activities are also sources of innovation (Zhou and Wu, 2010) and by the establishment of cooperative agreements, firms may

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ISSN: 0718-2724. (http://jotmi.org)

increase their capabilities which could have an impact on both their innovation inputs and outputs. Nevertheless, these types of agreements may be used by firms to build basic capabilities in order to engage in innovation later on, which could delay their effects.

Cooperative agreements in non-R&D activities are likely to increase investment in non-R&D innovation activities, but they may also induce firms to invest in R&D as these agreements may allow firms to develop technological capabilities over which they can construct the R&D capabilities that are decisive to perform R&D (Chaminade and Vang, 2008). Additionally, we also expect that the firms with these types of agreements are more likely to create new methods, processes and products. However, as these activities are mostly related to the absorption of technology, we expect that their linkages will produce greater effects on new-to-the-firm innovations rather than in the introduction of new-to-the-market innovations.

Furthermore, as there is evidence that R&D cooperation has positive effects on firms' ability to introduce organizational and marketing innovations (Sánchez-González, 2014; Simao and Franco, 2015), we are also interested in evaluating whether non-R&D cooperation also has an effect on them. Furthermore, we are interested in evaluating whether the combination of R&D and non-R&D linkages produces additional effects, as there may be complementarities between the two.

Lastly, as the effects of cooperation may differ depending on the type of partner with which the firms cooperate (Shin et al., 2016), we also need to take into account that the cooperative agreements of firms in developing countries not only differ from those of the developed world in terms of the type of activities, but also in the type of partners with which these agreements are established. For instance, in developing countries only a small proportion of the firms have developed cooperative agreements with science and technology institutions and the most common links are established with customers and suppliers and to a lesser extent with competitors (Anlló and Suárez, 2008).

3. Data and variables

We use data from the ENAI 2013 which contains information on 2,815 firms for the period 2009-2011. However, our analysis only covers 1,521 innovative firms as they are the only ones that answer the question on cooperation.

In relation to cooperation variables, ENAI provides information on the type of innovation activity in which firms cooperate (R&D, engineering and design, training, technical assistance, information and product testing) and on the type of partner (suppliers, clients, competitors, universities, laboratories and R&D firms, public organizations of science and technology). Although by combining this information we can create different types of cooperation variables, if one is aiming to analyze the impact of cooperation two aspects should be taken into account. First, it is important to be aware of the presence of potential hidden treatments (Guerzoni and Raiteri, 2015), as there are firms that collaborate in several activities with different partners at the same time. Thus, a hidden treatment might be represented by an additional cooperative agreement that can be used by the firm to obtain the same results. Therefore, if this is not taken into account, it is impossible to conclude that the observed innovation outcome is due to a specific cooperative agreement or to the use of another non-considered relationship or to the interaction of diverse cooperative agreements. To deal with this issue, we have decided to evaluate the impact of cooperation for firms that have exclusively one type of cooperative relationship. Second, in order to obtain credible standard errors we need to evaluate the impact of the cooperative agreements for which there are a sufficient number of cooperating firms. Table 1 shows the frequency of the exclusive cooperation variables for which we have a sufficient number of observations which will constitute our treatment variables.

Table 1. Exclusive cooperation variables with a sufficient number of observations

	Frequency
Only non-R&D cooperation	1198
R&D and non-R&D cooperation	97
Only cooperation in information	409
Only vertical non-R&D cooperation	733
Only vertical cooperation in information	228

Source: ENAI 2009-2011

Non-R&D cooperation refers to cooperation in the following innovation activities: engineering and design, training, technical assistance, information and product testing.

Vertical refers to suppliers and customers

As a starting point, we will assess the effects of two exclusive aggregate measures of cooperation. The first treatment is *Only non-R&D cooperation* which takes value 1 for firms that have at least a cooperative agreement in a non-R&D activity with any type of partner but that are not cooperating in R&D and 0 for firms that do not cooperate at all. The second variable is *R&D and non-R&D cooperation* taking on 1 for firms that collaborate in R&D with any type of partner and that also have at least a cooperative agreement in a non-R&D activity and 0 for non-cooperating firms. Note that we do not evaluate the impact of *Only R&D cooperation* as in our sample there are only 8 firms with this pattern. This shows that in the context of a developing country, R&D cooperation is only a marginal phenomenon although cooperation in non-R&D activities is widespread among innovative firms.

Then we evaluate the impact of the most frequent cooperation linkages by type of non-R&D activity. However, we only have a sufficient number of observations to evaluate the impact of cooperation in obtaining information as in developing countries the majority of the firms are in the first stage of the process of building technological capabilities to innovate which consists of accumulating the minimum essential knowledge base (Dutrénit, 2004). Thus, the third treatment is *Only cooperation in information* which takes value 1 for firms that cooperate exclusively in obtaining information regardless the type of partner and 0 for non-cooperating firms.

Finally, we aim at evaluating the impact of the most frequent cooperation agreements by type of non-R&D innovation activity and type of partner. In this case we only observe a substantial number of cooperating firms for vertical partners (clients and suppliers). We shall therefore analyze the impact of cooperation with vertical partners in non-R&D innovation activities and with vertical partners in obtaining information. We will refer to the former treatment as *Only vertical non-R&D cooperation*, which takes value 1 for firms that cooperate exclusively with clients or suppliers in at least one non-R&D innovation activity and 0 for non-cooperating firms; while the latter will be named *Only vertical cooperation in information*, taking on 1 for firms that cooperate exclusively with clients or suppliers in obtaining information and 0 for firms that do not cooperate at all. Note that all cooperation variables refers to the period 2009-2011.

Regarding outcome variables, we consider two innovation inputs and 6 outputs. Innovation inputs are *R&D intensity*, which is measured as the natural logarithm of 1 plus internal and external R&D expenditures divided by the total number of employees, all measured in 2011, and *Non-R&D intensity*, which is measured as the natural logarithm of 1 plus investments in the acquisition of machinery and equipment, of hardware, of software, of disembodied technology, contracting of consultancies and technical assistance, engineering and industrial design, staff training and market studies divided by the total number of employees, all measured in 2011. While for innovation outputs we consider the following dichotomous variables: *new to the market product*, *new to the firm product*, *new to the market process*, *new to the firm process*, *organizational innovation* and *marketing innovation.* These variables take value 1 if the firm introduced the specific innovation during the period 2009-2011 and 0 otherwise.

4. Methodology

Given that firms select themselves into cooperation, it is unlikely that firms that cooperate have the same characteristics as other firms. Moreover, if the characteristics that influence the cooperation decision also condition the outcome variables, the estimated coefficients of cooperation would be biased. Thus, in order to obtain the causal effect of cooperation, we employ inverse probability weighting (IPW) (Hirano et al., 2003) which is a propensity score method (Rubin and Rosenbaum, 1983). The propensity score is the conditional probability that a firm has selected itself to cooperation given an observed set of covariates. Once the propensity score is estimated through a probit model, IPW estimates the average treatment effect on the treated (ATT) by weighting cooperating firms by the inverse propensity score and non-cooperating firms by the inverse of 1 minus their propensity score (Rosenbaum, 2005). By doing this, IPW creates a pseudo-population in which the covariates and the treatment assignment are independent of each other. Once propensity scores are calculated, the ATT may be estimated using a regression model that incorporates the weights.

The success of IPW in estimating the ATT relies on two assumptions. The first, known as *unconfoundedness*, implies that the distribution of each potential outcome is independent of the random treatment, conditional on the covariates. Therefore, it requires the absence of any unobserved confounders and a high degree of post-match balance across observable covariates. The first requirement is untestable but it requires the propensity score model to include an adequate set of covariates. In this sense, it is more important to include either those covariates related to outcomes or those related to treatment and outcomes than to include those variables that affect exclusively the treatment-selection process (Austin et al., 2007). Consequently, in the estimations of the different propensity scores, we include in the vector of covariates an important set of factors that may influence both cooperation and outcome variables. Additionally, as the *unconfoundedness* assumption is not directly testable, its plausibility can often be assessed using lagged values of the outcomes as pseudo outcomes (Imbens, 2015); thus, we include the lagged values of *R&D intensity* and *Non-R&D intensity* both measured in 2009. Appendix 1 describes the set of covariates included in the propensity score equations and Appendix 2 shows the results of the probit models for the different types of cooperation variables.

As mentioned above, in order to show that the *unconfoundedness* assumption may hold, it is important to check whether IPW has generated a post-match balance across observable covariates. To show this, Table 2 indicates the model-adjusted difference in means and ratio of variances between the treated and untreated for each covariate for the treatments *Only non-R&D cooperation and R&D and non-R&D cooperation* (Appendix 3 displays the balance tests for the rest of the cooperation variables which show that differences in weighted means are negligible and that variance ratios are all near one, indicating that balance was successful for these treatments).

Tabla 2. Covariates balance test

	Only non-R&D Cooperation				***R&D and non-R&D Cooperation***			
	Standardized differences		Variance ratio		Standardized differences		Variance ratio	
	Before IPW	After IPW	Before IPW	After IPW	Before IPW	After IPW	Before IPW	After IPW
R&D intensity_2009	0.165	-0.064	1.290	0.917	0.692	-0.072	1.741	0.929
Non-R&D intensity_2009	0.170	-0.029	1.119	1.002	0.587	-0.010	1.059	0.993
Size	-0.093	0.034	0.942	1.078	0.374	0.118	1.342	0.932
Investment	0.252	0.019	1.004	1.129	0.563	0.032	0.920	1.145
Start-up	0.035	-0.018	1.138	0.940	0.070	-0.129	1.294	0.687
Exporter	-0.072	0.013	0.867	1.027	0.204	0.010	1.358	1.012
Group	-0.004	0.026	0.987	1.058	0.130	0.061	1.280	1.112
Qualification	-0.093	0.002	0.735	1.008	0.149	0.043	1.467	1.102
Sectorial cooperation	0.133	-0.009	0.953	1.080	0.273	-0.035	0.875	1.265
Advanced region	-0.262	0.031	1.212	0.987	-0.183	0.098	1.172	0.950

As we can see, before applying IPW differences were large. However, after applying IPW differences in weighted means are negligible, and variance ratios are all near one. This indicates that we have a high degree of post-match balance across our observable covariates. However, after weighting, we obtain a better balance on observables for the treatment *Only non-R&D cooperation* than for *R&D and non-R&D cooperation*. In the case of the latter, we still observe differences between treated and controls in relation to the variables *Size* and *Start-up*.

An alternative way of checking for good balance on observable covariates after applying IPW is to perform a chi square overidentification test in which null hypothesis considers that the covariates are balanced. Table 3 displays these tests for the different treatment variables.

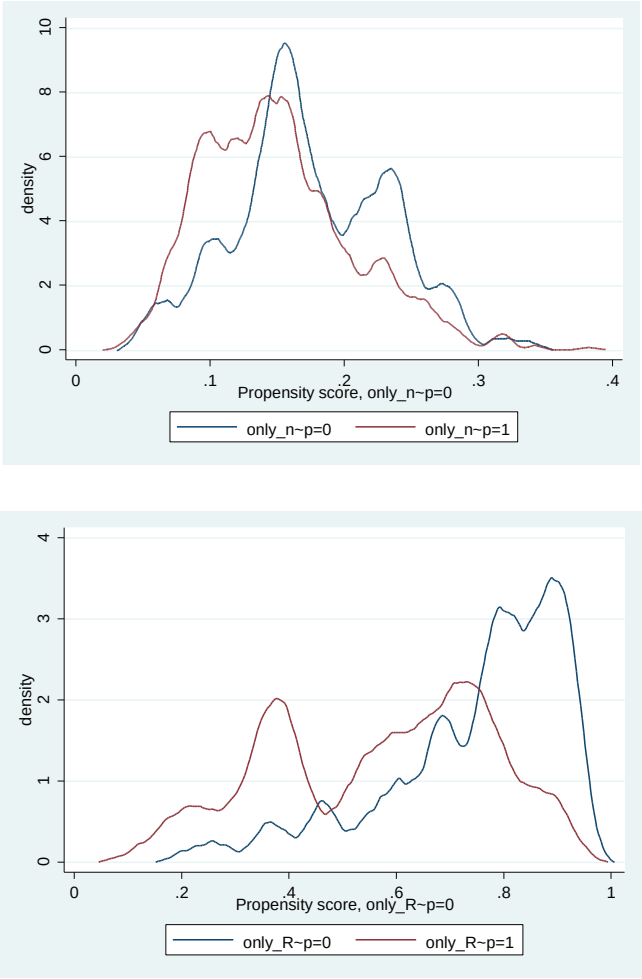
Table 3. Covariates chi square balance test

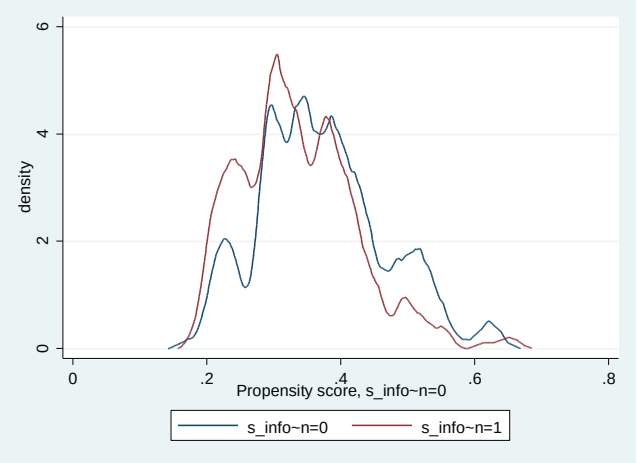
Treatment	Chi square
Only non-R&D cooperation	8.518 (0.666)
Only R&D and non-R&D cooperation	12.751 (0.310)
Only cooperation in information	3.890 (0.973)
Only vertical non-R&D cooperation	7.900 (0.722)
Only vertical cooperation in information	6.610 (0.830)

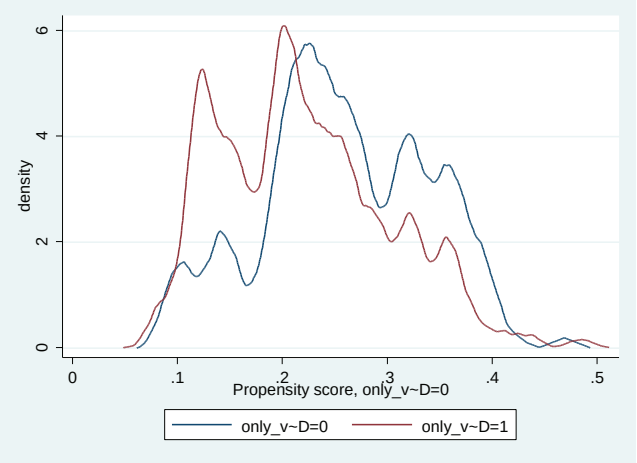
As we can see from Table 3, we cannot reject the null hypothesis that the covariates are balanced indicating that IPW has been successful in balancing covariates for all the different treatments.

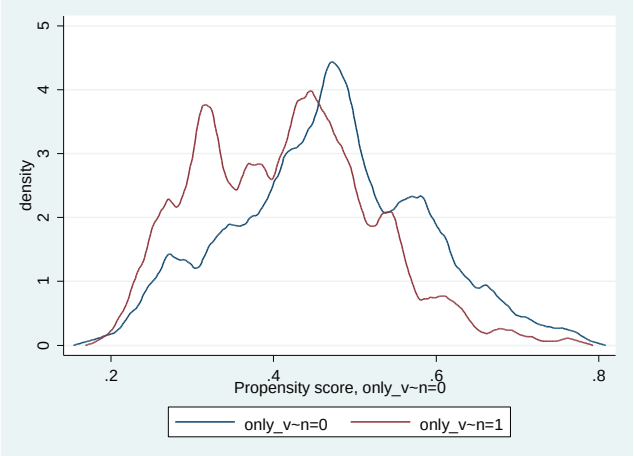
The second assumption is the *overlap assumption* which states that each firm has a positive probability of cooperating. This ensures that we have enough firms with the same covariates in both groups (treated and control). A common way of checking for this is to compare the estimated densities of the probability of getting each treatment of the treated group with that of the controls. Figure 1 shows these densities for our different treatment variables.

Figure 1. Estimated densities of the probability of cooperating









From top to bottom and left to right: Only non-R&D cooperation, R&D and non-R&D cooperation, Only cooperation in information, Only vertical non-R&D cooperation, Only vertical cooperation in information.

As we can see from the different graphs, neither plot indicates too much probability mass near 0 or 1 and that for every treatment the two estimated densities have most of their respective masses in regions in which they overlap each other. Therefore there is no evidence that the overlap assumption is violated.

5. Empirical results

Table 4 displays the ATT for the treatments *Only non-R&D cooperation* and *R&D and non-R&D cooperation* on the different types of innovation inputs and outputs.

Table 4. Impact of non-R&D cooperation and R&D and non-R&D cooperation (ATT) on the innovation inputs and outputs.

	Only non-R&D cooperation	R&D and non-R&D cooperation
R&D intensity	-0.250	1.318
	(0.187)	(0.376)***
Non-R&D intensity	0.079	0.714
	(0.218)	(0.384)*
New to the market product	0.033	0.198
	(0.036)	(0.069)***
New to the firm product	0.188	0.158
	(0.039)***	(0.071)**
New to the market process	0.006	0.103
	(0.036)	(0.071)
New to the firm process	0.020	0.124
	(0.039)	(0.071)*
Organizational innovation	0.093	0.178
	(0,036)**	(0,072)**
Marketing innovation	0.088	0.212
	(0.036)**	(0.072)***

Notes: *significant at 10%, **significant at 5%, ***significant at 1%

Regarding the impact on innovation inputs, results indicate that cooperation only in non-R&D activities does not affect either expenditures in R&D or in non-R&D activities. By contrast, the combination of R&D and non-R&D networks stimulates both types of investments. This indicates that non-R&D collaborative agreements are not enough to build the technological capabilities that induce firms to invest more in innovation activities, unless they are combined with cooperation in R&D activities. These results suggest that non-R&D linkages may be used by firms to build the minimum essential knowledge base to survive in the market and that during this process firms seem to postpone their investments in innovation activities probably until they have built advanced technological capabilities in technical functions and complex knowledge bases (Dutrénit, 2004). By contrast, firms that are also cooperating in R&D activities seem to be using their networks to nurture and renew strategic capabilities, which leads them to invest more in R&D and in other innovation activities. Therefore, firms need to cooperate in R&D activities in order to develop the technological capabilities that are required to encourage innovation.

In relation to the effects of these two treatments on product innovation, results indicate that cooperation only in non-R&D activities increases the likelihood of introducing new-to-the-firm products, while the combination of R&D and non-R&D cooperation enables the introduction of new-to-the-market and new-to-the-firm products.

Therefore, non-R&D linkages seem to be used by the firms to accumulate the necessary knowledge to introduce products that already exist in the market but that the firms do not have sufficient knowledge and capabilities to produce by themselves. By contrast, R&D cooperation seems to be orientated towards the introduction of products that are not yet on the market, which is not surprising as more radical innovations normally require investments in R&D activities and the use of a large variety of sources of information and collaborative agreements with external partners (Landry and Amara, 2002; De Faria, et al., 2010)

Results also indicate that cooperation only in non-R&D activities does not produce a significant impact on any type of process innovation, while R&D and non-R&D cooperation increases the likelihood of introducing new-to-the-firm processes, although the effect is only significant at 90%. This indicates that cooperative agreements in Ecuador are clearly more orientated towards the improvement of quality rather than the reduction of costs.

Finally, both treatments increase the likelihood of introducing marketing and organizational innovations, which is not surprising given that collaborative agreements are mainly established with customers and suppliers. As Radicic et al. (2015) indicate, while cooperation with customers can be of primary relevance for marketing innovations, cooperation with suppliers could be more focused on organizational innovations. In addition, it is important to highlight that the effects on marketing and organizational innovations are clearly greater for the treatment *R&D and non-R&D cooperation* than for *Only non-R&D cooperation* which indicates that there are complementarities between R&D and non-R&D cooperation when it comes to non-technological innovations.

Although the results discussed above give some insights on the effects of non-R&D cooperation in developing countries, they could be somewhat misleading, as cooperation in non-R&D activities includes a diverse set of activities that could have different effects on the inputs and outputs of the innovation process. In the same way, these different activities may be carried out with a variety of partners and it is also likely that different partners produce dissimilar effects (Shin et al., 2016). Consequently, Table 5 displays the ATT for the different exclusive cooperation variables by type of non-R&D innovation activity and by type of partner.

Table 5. Impact of cooperation by type of partner and innovation activity (ATT) on the innovation inputs and outputs.

	Only cooperation in information	Only vertical non R&D cooperation	Only vertical cooperation in information
R&D intensity	-0.334	-0.279	-0.316
	(0.182)*	(0.186)	(0.201)
Non-R&D intensity	0.015	0.069	0.138
	(0.233)	(0.225)	(0.253)
New to the market product	0.021	0.018	0.009
	(0.039)	(0.038)	(0.043)
New to the firm product	0.182	0.163	0.179
	(0.043)***	(0.042)***	(0.048)***
New to the market process	-0.012	-0.002	0.007
	(0.036)	(0.037)	(0.041)
New to the firm process	-0.045	0.012	-0.061
	(0.044)	(0.041)	(0.048)
Organizational innovation	0.091	0.069	0.075
	(0.039)**	(0.037)*	(0.043)*
Marketing innovation	0.044	0.062	0.029
	(0.039)	(0.038)	(0.043)

Notes: *significant at 10%, **significant at 5%, ***significant at 1%.
Vertical refers to suppliers and customers

The first treatment is *Only cooperation in information* which does not take into account the type of partner. The significant effects for this treatment indicate that firms that cooperate exclusively in obtaining information show a lower R&D intensity than non-cooperating firms, although this result is only significant at 90%. This would suggest that firms that exclusively cooperate in obtaining information use their networks to absorb the basic initial knowledge that they will require in the future in order to innovate. Meanwhile, firms seem to reduce their investment in R&D activities while their non-R&D innovation expenditures remain unaltered. Thus, cooperation in obtaining information seems to be a preliminary state of networking for firms that have not already developed advanced capabilities and have decided to postpone their innovation activities. Moreover, as firms that cooperate exclusively in obtaining information are also more likely to introduce new-to-the-firm products and organizational innovations, it seems that the type of information that firms are looking for through these agreements is related to the knowledge needed to introduce products that already exist in the market, which are also likely to require organizational changes. The positive effect on organizational innovation could also indicate that cooperation in obtaining information may allow firms to build up managerial capabilities that allow firms to adopt flexible structures that facilitate doing, using and interacting modes of learning which can prepare firms to engage in more complex innovation activities in the future (Lundvall, 2007).

The other two treatments (*Only vertical non-R&D cooperation* and *Only vertical cooperation in information*) are very similar variables, as the majority of firms that cooperate exclusively with vertical partners in non-R&D activities do so for the purpose of obtaining information. This may explain why both treatments show similar effects. As expected, given the previous results, firms with these patterns of cooperation are more likely to introduce new-to-the-firm product and organizational innovations. Therefore, the negative and significant effect at 90% that we found for the treatment *Only cooperating in information* on R&D intensity seems not to be associated with cooperation with vertical partners but with research institutions and competitors. Hence, in developing countries the majority of the firms establish cooperative agreements with suppliers and customers with the purpose of obtaining the required knowledge to introduce products that their competitors already have in the market and this type of innovation seems to require complementary organizational changes. Moreover, although these types of collaborative agreements do not affect the efforts of firms to innovate, as obtaining information is likely to be a preliminary stage in the process of building technological capabilities and also produces organizational changes, it is likely that with the passage of time the knowledge that the firms acquire through these relationships eventually strengthen their capabilities, which would stimulate future innovation activities.

Conclusion

Since innovation surveys do not provide information on cooperation in innovation activities that are not R&D, empirical studies on the effects of collaborative innovation have merely evaluated the impact of cooperation in R&D activities. However, in developing countries, R&D cooperation is only a fringe phenomenon, although most innovative firms are cooperating in other innovation activities such as engineering and design, training, technical assistance, product testing and above all in obtaining information. Firms in developing countries are mainly collaborating in these activities as they do not have sufficient technological capabilities to perform R&D activities (Fernández-Sastre and Martín-Mayoral, 2016). Nevertheless, by the establishment of cooperative agreements in non-R&D activities, firms may access external knowledge and resources which may lead to an extension in their technological capabilities and thus to increasing their innovation expenditure and the likelihood of introducing innovations. However, although these innovation linkages may have an impact on firms' innovative behavior and performance their efficacy has not yet been tested.

Drawing on data from the ENAI 2013, which provides information on the different innovation activities in which firms cooperate, this paper evaluates the effects of cooperating in non-R&D activities on firms' innovation inputs and outputs. Furthermore, it evaluates whether the combination of R&D and non-R&D relationships produce additional effects.

In order to estimate the causal effects, we deal with selection bias by using IPW, while in order to prevent our results from being affected by the presence of additional cooperative relationships, we focus on firms that have exclusively one type of relationship. Moreover, since in order to obtain credible standard errors, we need a sufficient number of cooperating firms, we evaluate the impact of the following exclusive cooperative agreements which are the ones most used in Ecuador: *Only non-R&D cooperation*, *R&D and non-R&D cooperation, Only cooperation in information, Only vertical non-R&D cooperation* and *Only vertical cooperation in information*.

Our findings indicate that cooperation in non-R&D innovation activities positively affects the introduction of new-to-the-firm product, marketing and organizational innovations, while cooperation in both R&D and non-R&D activities also have effects on R&D intensity and new-to-the-market product innovation and also produce greater effects on marketing and organizational innovations. Additionally, firms that cooperate exclusively in obtaining information, which is mainly carried out with suppliers and customers, are more likely to introduce new-to-the-firm product and organizational innovations.

Based on these results, it is argued that non-R&D cooperation seems to be used by firms to build the minimum essential knowledge base, as it mainly serves to introduce products that already exist in the market. Moreover, the positive effects on marketing and organizational innovations could indicate that non-R&D cooperation may also allow firms to build up managerial capabilities to engage in more complex innovation activities in the future. By contrast, firms that are also cooperating in R&D activities seem to be using their networks to strengthen technological capabilities which leads them to invest more in R&D, allowing them to introduce new-to-the-market product innovations.

Our findings have important policy implications for developing countries, as they suggest that technology policies should not focus exclusively on scientific modes of learning and consequently on formal R&D. In developing countries, those policies supporting competence building and the absorption of technology and information should be more effective (Chaminade et al., 2010) as the majority of the firms are still accumulating the minimum essential knowledge base to survive in the market (Dutrénit, 2004). Therefore, it may be later on - once firms have developed technological and managerial capabilities and the national innovation system contains advanced R&D organizations and institutions that allow firms to establish satisfactory R&D networks - that R&D cooperation should be encouraged.

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Appendix

Appendix 1. Covariates in the probit propensity score model

Variable	Description
R&D intensity_2009	Natural logarithm of 1 plus firms' internal and external R&D expenditures divided by the total number of employees in 2009
Non-R&D intensity_2009	Natural logarithm of 1 plus firms' expenditures in the acquisition of machinery and equipment, acquisition of hardware, acquisition of software, acquisition of disembodied technology, contracting of consultancies and technical assistance, engineering and industrial design, staff training and market studies divided the total number of employees in 2009
Size	Natural logarithm of firms' number of employees in 2011
Investment	Natural logarithm of 1 plus firms' investment in fixed capital divided by the total number of employees in 2011
Startup	Dummy variable taking on 1 for firms that are for 3 or less years in the Ecuadorian market
Exporter	Dummy variable taking on 1 for exporters and 0 otherwise
Group	Dummy variable taking on 1 for firms that belong to a business group and 0 otherwise
Qualification	Dummy variable taking on 1 for firms that have at least a PhD between their employees
Sectorial cooperation	Average sector level cooperation in any type of innovation activity
Advanced region	Dummy variable taking on 1 for firms located in the most advanced regions of Ecuador (Guayas or Pichincha) and 0 otherwise.

Appendix 2. Propensity score probit models

	Only non-R&D Coop	Only R&D & non-R&D Coop	Only cooperation in information	Only vertical non-R&D cooperation	Only vertical cooperation in information
R&D intensity_2009	0.030	0.125	0.012	0.020	0.029
	(0.018)	(0.031)***	(0.023)	(0.019)	(0.025)
Non-R&D intensity_2009	0.013	0.040	-0.008	0.005	-0.016
	(0.013)	(0.027)	(0.017)	(0.014)	(0.019)
Size	-0.039	0.101	-0.089	-0.043	-0.086
	(0.034)	(0.061)	(0.045)**	(0.038)	(0.049)
Investment	0.039	0.066	0.033	0.041	0.027
	(0.012)***	(0.025)***	(0.016)**	(0.013)***	(0.017)
Startup	0.042	0.312	0.099	0.112	0.186
	(0.176)	(0.318)	(0.221)	(0.192)	(0.236)
Exporter	-0.129	-0.174	-0.246	-0.092	-0.269
	(0.125)	(0.220)	(0.168)	(0.141)	(0.187)
Group	0.064	-0.068	0.049	0.015	-0.047
	(0.124)	(0.237)	(0.163)	(0.142)	(0.186)
Qualification	-0.174	0.018	-0.271	-0.275	-0.344
	(0.159)	(0.264)	(0.213)	(0.182)	(0.241)
Sectorial cooperation	0.609	1.994	-0.006	0.638	0.429
	(0.522)	(1.076)*	(0.665)	(0.582)	(0.731)
Advanced region	-0.264	-0.214	-0.243	-0.367	-0.343

Notes: *significant at 10%, **significant at 5%, ***significant at 1%

Appendix 3. Covariates balance test

	Only cooperation in information				**Only vertical non-R&D cooperation**				**Only vertical cooperation in information**			
	Standardized differences		Variance ratio		Standardized differences		Variance ratio		Standardized differences		Variance ratio	
	Before IPW	After IPW	Before IPW	After IPW	Before IPW	After IPW	Before IPW	After IPW	Before IPW	After IPW	Before IPW	After IPW
R&D intensity_2009	0.025	-0.021	1.108	1.003	0.099	-0.054	1.236	0.965	0.053	-0.043	1.242	1.035
Non-R&D intensity_2009	-0.015	-0.003	1.040	0.997	0.105	-0.025	1.125	1.006	-0.028	-0.009	1.054	0.995
Size	-0.253	-0.005	0.771	1.065	-0.131	0.024	0.925	1.094	-0.285	0.004	0.760	1.110
Investment	0.129	0.009	0.982	1.059	0.235	0.023	1.023	1.146	0.093	0.003	0.979	1.044
Start-up	0.056	-0.003	1.223	0.988	0.071	-0.029	1.285	0.911	0.092	-0.012	1.381	0.962
Exporter	-0.200	0.008	0.639	1.021	-0.084	0.002	0.845	1.004	-0.219	0.006	0.606	1.017
Group	-0.053	0.008	0.887	1.019	-0.044	0.030	0.905	1.074	-0.107	0.014	0.777	1.039
Qualification	-0.141	0.004	0.611	1.017	-0.133	-0.006	0.631	0.977	-0.165	0.013	0.552	1.059
Sectorial cooperation	0.038	0.008	0.976	0.988	0.135	-0.007	0.943	1.055	0.097	0.001	0.958	1.028
Advanced region	-0.233	0.007	1.197	0.996	-0.346	0.021	1.250	0.995	-0.310	0.028	1.239	0.991

Semantic test of a technology management model in family business

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Abstract: This paper assembles family business conceptions from the innovation and technology management perspective, and tests them in the case of a Mexican sugarcane producer. Literature indicates that non-financial objectives, risk aversion and strong controls negatively influence family firms' innovation outcomes. Based on semantic network analysis, we collected transversal information on the firm's technology activities, innovation values and organizational flows, which allowed for the identification of an organizational management profile that shapes an innovation style. Although we acknowledge literature consistency in aspects such as family direct influence and control, or the importance of STI partnerships and external knowledge, our findings didn't identify any concerns about losing control in parts of the family business. This research contributes to the understanding of technology management and organizational elements in an emerging economy's family firm from a relational perspective. Implications for theory endorsement and characterization of family business innovation and technology management in developing countries are discussed.

Keywords: Family business; Management of technology; Innovation; Network analysis.

Submitted: June 21st 2017 / Approved: September 28th 2017

1. Introduction

Innovation has long been considered essential for business growth (Aghion and Howit, 1992), especially in the context of globalization and hyper competition. A variety of organizational and strategic behaviors in family businesses have been identified, though our knowledge about the relation between family business behavior and innovation remains limited (De Massis, Frattini & Lichtenthaler, 2013; Diéguez-Soto, Manzaneque & Rojo-Ramírez, 2016). Continued research in this topic becomes therefore necessary, which improved understanding would help us identify determinants for family firm development. Family firms represents a significant share of total businesses worldwide, estimated between 65% and 90% of all companies (Durán and San Martín, 2016), which are obliged to face greater vulnerability as a consequence of a complex intertwining between business and family goals. This challenging relationship raises important research questions in terms of organizational structure, management styles, performance and innovation.

This research focuses on illustrating family business behavior from a technology management model approach, and tests expected family business innovation literature, including family business innovation behavior and technology management models. The semantic methodology perspective is explained, followed by findings and conclusions.

2. Literature Review

2.1. Family business behavior

Family business can be defined as a legally incorporated firm, which ownership is predominantly in the hands of a single family, and at least one family member has an executive position in the firm's top management (Gallo and Sveen, 1991). Since the firm's incorporation, family businesses exhibit distinctive behaviors, namely, a) the alignment of objectives between the owner and the executive, avoiding agency costs, as both functions merge into the same person (McConaughy et al., 1998); b) long-term project business interest approach that simultaneously protects the family interests (Mazzola, 2002); and c) internal generation of strategic resources (San Martín et al., in process).

Although there has been significant research in the subject, results are still inconclusive. Some scholars show that growth is not an organizational priority in these businesses (Zahra, 2005; De la Garza et al., 2015), prevailing family's non-economic objectives (Berrone, et al., 2012). Other studies indicate the opposite behavior: family firms seem to prioritize sales growth and net assets (Leach and Leahy, 1991), higher growth (Habbershon and Pistrui, 2002); aggresive internacionalization (Davis and Haverson, 2000); resource provisioning for development (Le Breton-Miller and Miller, 2006); and greater potential for innovation (Aronoff, 1998). Imminently, family businesses grow, either as a result of organizational structure or the family's management style (Fuentes et al., 2008).

Different factors affect family firm's innovation behavior, including a dominant role of the owner-founder, who bases her decisions on intuition, knowledge, experience and vision; Mintzberg et al. (1999) call it *visionary process*. Usually, the family's desire to keep control of their business represents an access barrier to venture capital investment opportunities (Gómez-Mejía, Cruz, et al., 2011). Additionally, this process creates an incompatibility between managerial competencies and ambitious innovation projects (Block et al., 2013). According to Block et al. (2013), family firms are placed into a decision dilemma: whereas more investment in significant innovations might enhance competitiveness and sustainable performance, it could also reduce family control. To answer that dilemma, family firms have shown

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strong preferences for incremental innovation projects, which allow them to have less economic and technical uncertainty and higher management control capacity.

On the one hand, the pursue of growth obliges family businesses to revitalize their strategy, attracting and retaining competent managers outside the family, fostering flexibility and organizational innovation, generate and preserve financial wealth and prepare a successor to lead the business (Ward, 1997). Vallejo (2003) considers that flexibility and speed in the decision-making process are core advantages in family businesses. Expectedly, proprietors would need to incorporate new shareholders and professional managers unrelated to the family, involving new governance configurations that require decreasing functional complexity and specific role definition for all stakeholders involved. However, proprietors would be reluctant to delegating control and may resort to "quasi-organic" structures. In this form of organization, control is passed to the executives, though owners maintain proprietorial prerogatives with arbitrary interventions (Goffe and Scasse, 1985).

When confronted to new challenges, organic organizations seem more useful, as their characteristics allow for: a) a change in decision-making from vertical to horizontal cooperation, considering that the composition of the organization consists of a maximum number of strategic top management groups and project teams (McCalman, 1996); b) departmental barriers erosion to facilitate the work of cross-functional teams and integration of specialized knowledge (Cross, 2000); c) directors' authority is granted to employees (decentralization of power and control) to participate in organizational management, proactively promoting a culture of openness and trust (Hankinson, 1999); d) higher level of informality and freedom of rules, where management grows to lead people, technology, knowledge and processes. In general, stimulus for member interaction is treated as main mechanism for creating new knowledge (Wang and Ahmed, 2003).

This research focuses on family business from an innovation perspective, which is expected to contribute to the firm's long term strategy from a technology management model approach.

2.2. The management of technology

Technology management can be defined as a discipline which central task is to guarantee the firm's technological competitive position within a given business strategy for a product-market relationship, involving research, product and process development management, engineering and usage of information and communication technologies (Rastogi, 1995). Its application includes a variety of considerations around the innovation phenomenon, with particular focus on the firm's impacts in terms of organizational structure and processes, stakeholders interactions (owners, employees and partners), practices, and contextual specificities (Medellin, 2010). The firm's innovation complexity can go from strategic technology acquisitions and adaptation to incremental or radical developments, and the scope of technology management includes the whole strategic planning and coordination of organizational activities (Rastogi, 1995), with the purpose of fostering technology innovation, new value-creation processes and creative commercialization models (Medellin, 2010).

In the end, technology management targets the firm's innovation. However, in order to accomplish this goal, it is important that the firm complies with certain conditions for an effective management of technology, including an appropriate framework that relates the firm's technologies, capabilities and business objectives, integrated functional teams capable of implementing innovations, technology exploitation capabilities, a technology management system, and accountable staff (Medellin, 2013). Rastogi (1995) simplifies these requirements by emphasizing the firm's ability to perceive a need for change in its technology base, as a result of the competitive environment, and subsequent skills to implement change.

At some extent, the implementation of technology management in a firm requires also innovation at the firms' management level. This fact would imply the application of new knowledge to amend the nature of the firm's organizational practices to comply with stronger technology functions (Mol and Birkinshaw, 2014). However, little research has been devoted to understanding the relationship between technology management and the organizational elements that explain it such as purpose, structure, processes and activities (Medellin, 2013). Following a design perspective, organizational structures can take either the form of social constraint (hierarchical) or social action (emergent from the bottom-up) organizations (Dougherty, 2008), which would determine the appropriate organizational path to implement technology management. Additionally, the intrafirm transfer of the employees' knowledge usually involves forms of social capital that may result in innovation performance, requiring the presence of mediation mechanisms (Maurer, Bartsch, & Ebers, 2011).

From a family firm research perspective, which emphasizes the family's strong influence on the firm's decision-making process (De Massis, Frattini, & Lichtenthaler, 2013; Diéguez-Soto, Manzaneque, & Rojo-Ramírez, 2016), management innovation starts with the family owners. As a socially bounded organization, all flow of activities, integration of innovative work and emotional impulse to innovate go through the family (Dougherty, 2008). Thus, the role of mediator in the identification of useful resources, the establishment of effective socialization (business meetings), knowledge sharing (absorption) and collaboration for the transfer and circulation of ideas and knowledge goes to the family (Temel, Mention, & Torkkeli, 2013), who becomes either a facilitator or a barrier between the firm's social capital and the innovation outcome. Table 1 below summarizes relevant family firms' behaviors as identified by some scholars (De Massis et al., 2013; Diéguez-Soto et al., 2016). As indicated, family firms would have different patterns depending on short vs long term vision.

Table 1. Family Firms Innovation Behavior

	Axiom/ Hyphotesis	Questions
Short-Term Inneficiencies	The search for preservation of socieconomic wealth affects family firms' innovation intensity (Block, et al., 2013).	Does a family manager have direct influence on the firm's innovation strategy?
		Besides financials, does the firm seek non-financial objectives (e.g. emotional, social, etc.) in pursuing STI activities?
	Family firms tend to be risk averse (De Massis, Frattini, et al., 2013).	Is there risk-averse behaviour evidence in the firm's technology management model?
		Does the firm's technology management model include signs of strong family managers' control on STI project approval?
	Family managers are reluctant to conceding firm control to external partners/ investors (Czarnitzki & Kraft, 2009).	Does the firm's technology management model limit the influence of employed managers in the decision making process?
		Does the firm encourage or restrict STI partnerships?
		Does the firm loss control when partnering with external entities?
		Does the model prevent disruptive innovation?
Long-Term Efficiencies	Family firms refuse to invest in innovation if financial requirements exceed internal capabilities (Zahra, 2005).	
	Family firms are reluctant to seek external financing as this would involve loss of the firm control (Munari et al., 2010).	
	Family firms tend to invest less in innovation than non-family firms (Chen & Hsu, 2009).	
	Focus is on family objectives and values (Berrone et al., 2012).	
	Family firms support STI projects when innovation outcomes are obtained (proven technology). (McCann et al., 2001).	
	Long term outcomes motivate family firms to invest in new technology (Bergfeld & Weber, 2011).	
	Social capital (quality family relationships) contributes to enhance innovation strategies (Cassia, De Massis & Pizzurno, 2011).	
	Family firms may rely on external knowledge for innovation as a result of external social capital(Classen et al., 2012; Alberti & Pizzurno, 2013).	
	Connections with external stakeholders increase family firm performance as mental models and knowledge change.	

source: own elaborated based on De Massis et al. (2013) and Diéguez-Soto et al. (2016)

Research literature related to technology management has focused mainly on multinational enterprises, with little interest in smaller companies (Medellin, 2013) and fully agnostic to the particularities of family firms. This paper takes these family firms' innovation characteristics and maps them into a semantic network as explained further in this paper.

2.2.1. Technology Management Models

Several proposals have been put in place to model technology management at the firm's level. A technology management model (TMM) is an abstract representation of a firm's technology management system, which can be classified from different perspectives: functional, processes-oriented, based on key activities, or evaluation criteria (Medellin, 2013). There is a variety of TMM proposals in the literature (Bo and Qiuyan, 2012; Kearns, Taylor, & Hull, 2005; Medellin, 2013), which have even been applied not only in firms but also at the sectoral level (Liao, Hull, & Sriramachandramurthy, 2013; Luxmore and Hull, 2010).

As an instance, Kearns et al. (2005) have developed a model with six technology management facets: technology evaluation, integration, planning, implementation, training and change, which have been applied to particular sectoral cases. Medellin (2013) advocates for a model that goes beyond management elements as his TMM includes innovation capabilities while technology management involves technology strategy, organizational structure, processes and management skills, innovation capabilities refer to the firm's capacity to execute RandD, design, engineering and innovation projects, together with access to knowledge and external technologies (Medellin, 2013).

Other proposals include functional elements (optimization, enhancement, protection, inventory, assessment and surveillance), specific activities (identification, selection, acquisition, exploitation and protection) or a set of integrated considerations (technology acquisition mechanisms and sources, processes, and outcomes) (Medellin, 2013). In general, Medellin (2013) has identified TMM proposals from scholars and organizations in the United States, France, Spain, and Latin America.

In the case of Mexico, norm NMX-GT-002-IMNC-2008 has been created with the purpose of providing Mexican companies with guidance in identifying and managing technology projects. Additionally, this norm was designed to evaluate Mexican firms in terms of technology management and innovation processes. The Mexican norm was modeled after Spain's series of norms UNE 166000:2002 EX, which are consistent with the Frascati manual[1]. As Mexican model for technology management, NMX- GT-002-IMNC-2008 set the basis for the National Award in Technology and Innovation or PNTI[2], which is offered by the federal government to recognize innovative Mexican firms. Moreover, the award is seen as a motivation and dissemination mechanism that would encourage the adoption of the TMM between Mexican firms.

The Mexican TMM involves five key technology management functions[3]: surveillance, planning, habilitation, protection and implementation. Each function involves particular processes, which are listed next:

- Surveillance: benchmarking, market studies development, and technology monitoring.
- Planning: development and review of the technology plan and projects portfolio.
- Habilitation: technology acquisition, technology assimilation, technology development, technology transfer, project portfolio management, technical staff management, financial resource management, and knowledge management.
- Protect: intellectual property.
- Implementation: process, products, marketing and organizational innovations.

Though the model provides definitions for each item, it does not offer any details on how companies should implement the TMM, allowing for excessive flexibility and model interpretation. Mexican firms report their TMM to the PNTI and the winners' documents are made public in the PNTI website. Critics indicate that these documents report activities, not an actual model, without explaining how the firms' key technology management processes develop or particular objectives that support these processes (Medellin, 2013). Additionally, Medellin (2013) finds that most PNTI winners lack process consistency, systematization and efficacy, as well as an implementation methodology to constitute a technology management system.

In spite of criticism about the Mexican TMM, their PNTI reports provide valuable transversal information on the firms' technology activities, innovation values and organizational flows. **Research Methodoly**

To achieve our research objectives, This paper confronts what the literature claims about innovation in family firms to the web of textual meaning contained in Coprobamex' TMM document.

Coprobamex (http://www.coprobamex.com) is a Mexican family business incorporated in 1990 that specializes in the sugar industry. Founded by the the Bojorquez brothers, the company has evolved to create value-added sugar-based products, such as Sucraliq, which is liquid sugar, highly used in the food industry. Coprobamex is one the 2009 PNTI winners and the company's report on what they see as TMM offers details on how this family firm deals with innovation, disclosing organizational decision making flows, knowledge partnerships and company values. This information has helped us to determine literature consistency with the firm's innovation and technology management behavior. Taken as case study, Coprobamex' report has been used to test our analytical framework on family businesses' TMM.

On the one hand, based on the literature review summarized in table 1 above, we have come up with 15 meaningful interpretations of what characterizes family firms. These interpretations (features) are listed in table 2 below.

(1) http://www.oecd.org/sti/inno/Frascati-Manual.htm
(2) http://pnt.org.mx
(3) http://pnt.org.mx/modelo-nacional

Table 2. Family firms innovation behavior characteristiques

1.	Social Recognition
2.	Economic Wealth
3.	Innovation thinking
4.	Family member direct influence
5.	Risk-averse behavior
6.	Employees limitations in the decision making
7.	Encouragement of STI partnership
8.	Fear to loss control to external partners
9.	Model prevents disruptive innovation
10.	Refuse external finance
11.	Less investment in innovation
12.	STI supported if clear outcomes
13.	Family relations contribute to innovation
14.	Reliance on external knowledge
15.	External connection increases firm performance

Source: authors' extraction based on De Massis et al., (2013) and Diéguez-Soto et al., (2016)

Additionally, we have identified 8 key players related to specific functions and power relations according to the company's TMM. These actors are presented in table 3 below.

Table 3. Coprobamex key players related to TMM

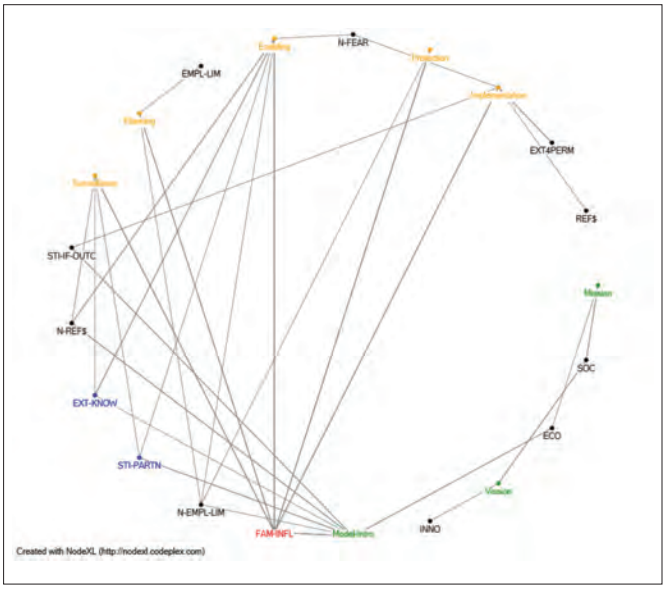
1.	Family-control (family members)
2.	Investors
3.	New-products
4.	Outcome-oriented (objectives)
5.	Partners (external)
6.	Society
7.	Stakeholders (the firm)
8.	Team (employees and owners)

Source: authors' extraction

Coprobamex TMM report is divided in 8 sections, including: 1) mission; 2) vision; 3) model introduction, and the model's five key functions; 4) surveillance; 5) planning; 6) habilitation; 7) protection; and 8) implementation, which are the main object of analysis. We assessed key concepts in each section and collected their meaning to map them into one of aforementioned interpretations. For example, if Coprobamex document indicates in its implementation section that the CEO of the company has a direct monitoring function on how each technology project is executed in order to guarantee that it complies with the firm's priorities, this is a clear indicator of strong family control on the business operations. Hence, interpretation "Family member direct influence" and key player "Family-control" become semantically related to the function "implementation". We mapped each semantic finding for "interpretations" to the corresponding "section" whenever the text indicated a new meaning. In parallel, we mapped the "key player" involved in the interpretation to the corresponding "section".

Using network analysis software (NodeXL), we graphically compared the 8 "sections" to semantic mappings for each of the "interpretations" (features) taken from the text. We also mapped "sections" to "key players". The results are available in the figures below.

Figure 1. Interpretation perspective map

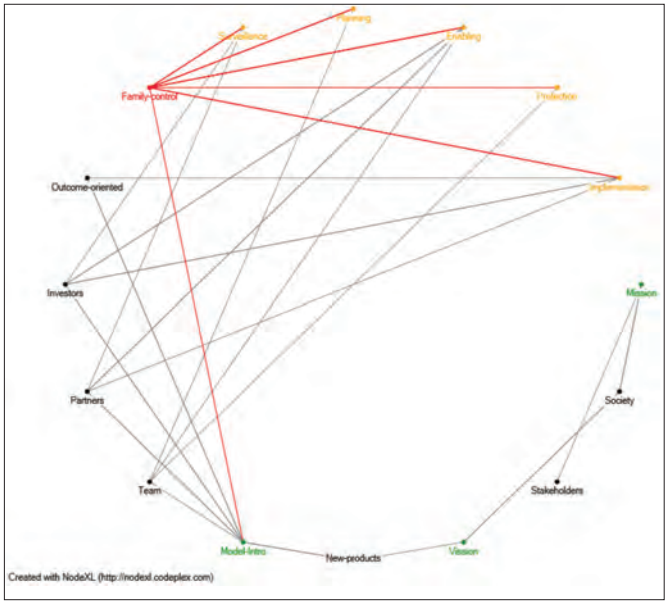


(N- denotes negative relation)

From the "interpretations" perspective, Figure 1 shows "Family member direct influence" (FAM-INFL) as the main node in the network, which has connections to all sections in the TMM. "Encouragement of STI partnership" (STI-PARTN) and "Reliance on external knowledge" (EXT-KNOW) have both links to the TMM surveillance and enabling functions. Interestingly, "Employees limitations in the decision making" (EMPL-LIM and N-EMPL-LIM) has a positive and a negative relation to planning. "Employees limitations in the decision making" has also negative links to the enabling and protection functions and "Fear to loss control to external partners" (N-FEAR) is negatively associated to enabling and implementation. Additionally, while "Refuse external finance" (REF$ and N-REF$) is negatively

related to enabling, it has positive participation in the implementation function. "External connection increases firm performance" (EXT4PERM) has also a positive connection to implementation. Finally, "STI supported if clear outcomes" (STI-IF-OUTC) is a concept mentioned in the implementation function and the introduction of the model.

Figure 2. Sections-Key Players perspective map



Similarly, Figure 2 puts together TMM sections and actors. Again, Family-control has connections to all the TMM functions. Both Investors and Partners relate to the surveillance, enabling and implementation functions. Team participation is present in the planning, enabling and protection functions. In the implementation and model introduction, the semantics indicates the importance of outcome-oriented meaning. This outcome is consistent with the "interpretations" perspective.

3. Results

From the network analysis shown above, it is possible to confirm some of the innovation features in a family firm behavior, as tested in the case of Coprobamex. Some short-term inefficiencies detected in the literature can be corroborated. The case under analysis confirms strong direct influence and control from the family, clearly signaled in both network analyses, endorsing findings in the literature about the family managers unwillingness to cede control (Diéguez-Soto et al., 2016). Particular TMM functions such as surveillance and enabling welcome STI partnerships and external knowledge, which is an indicator of the firm reliance on partners to identify new technologies and make their development a reality, as indicated by Alberti and Pizzurno (2013), De Massis et al. (2013) and Classen et al. (2012). Though employees do participate in the firm's planning process, their involvement seems limited, indicating strong controls as well (Czarnitzki & Kraft, 2009; Diéguez-Soto et al., 2016). However, the firm's staff has more participation in finding resources to develop the new product (enabling) and intellectual property protection, which is a fact that doesn't contradict the literature review as family control of the decision making process remains.

On the other hand, this case indicates that the firm is not concerned about losing control in some parts of the family business, as they are open to external resources and investment (enabling and implementation) within some limits (e.g. no external influence in the planning and protection functions), suggesting contextual boundaries to statements made by Munari et al. (2010). Concerning long term efficiencies, the firm's TMM confirms that STI would be supported if there are clear outcomes demonstrated in previous technology development phases (McCann et al., 2001), usually by partnering with RandD institutions. In general, external connections aim at increasing firm performance, confirming family firms' behavior as reported by scholars though bounded by Coprobamex' contextual elements.

4. Conclusions

Interweaving business and family goals would represent one of the main causes for underperformance. Family business control is established as a key factor for survival (Cisneros and Hernández, 2011); hence, the growing research interest in the subject.

In general, family businesses focus on formal control mechanisms, in opposition to organic or quasi-organic organizations. This is the natural result of family concerns to maintain control of the company and reduce the uncertainty caused by structural growth or the so-called institutional overlap. Usage risks are also recognized when such mechanisms threaten the firm's innovation capacity or their flexibility to face innovation challenges. Typical factors that hinder technology innovation include top management isolation, unreceptiveness to new ideas, excessive controls, and inappropriate incentives for innovators (Rastogi, 1995). Family firms tend to adopt these organizational inhibitors, as demonstrated in the case of Coprobamex.

In particular, it is instrumental that the organizational structure considers the role of the technology manager, who should be a knowledgeable and experienced professional in the field, and can make the linkage between enterprise strategy and technology as long as this figure is present in the firm's management board (Medellin, 2013).
The use of the TMM from an semantic network perspective has allowed for a family firm innovation behavior characterization. Though the model may have several limitations for real implementation, since it has been written by the family firm itself, the information provided becomes valuable to understand the firm's values and thinking about innovation.

For future research, we suggest further characterization of more family businesses' innovation behavior in developing countries, which would allow for targeted enterprise development policies, especifically family-owned SMEs. Additionally, we believe that the methodological framework presented in this paper is an original contribution to research that can be extended to a larger set of business types, gaining external validity if a relevant number of companies is considered.

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La cooperación tecnológica universidad-empresa: el rol de la comunicación

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Abstract: El trabajo aborda la cooperación tecnológica entre universidad y empresa bajo el enfoque de redes, discutiendo la importancia del comportamiento de comunicación. Se analiza cómo la comunicación se relaciona con el éxito de la transferencia de conocimiento y si existen diferencias en la relación entre ambas variables en función de la modalidad bajo la que se desarrolla la cooperación. La aplicación empírica en España evidencia que una comunicación adecuada, oportuna, completa y creíble entre los miembros de la empresa y del equipo de investigación universitario se asocia positivamente con el éxito de la transferencia de conocimiento. Además, cuando el acuerdo se desarrolla bajo la forma de investigación cooperativa, se observa una mayor asociación entre el comportamiento de comunicación y el éxito de la transferencia de conocimiento. Así, se deriva la necesidad de que directivos e investigadores participantes en acuerdos de cooperación presten especial atención a la comunicación interorganizativa e intraorganizativa.

Palabras clave: transferencia de conocimiento; cooperación tecnológica; contrato de investigación y desarrollo; investigación cooperativa; relación universidad-empresa; redes; España.

Abstract: *Title: University-industry technology cooperation: the role of communication* / This paper examines university-industry technology cooperation, using the network approach and discussing the importance of communication behavior. We analyze the relationship between communication behavior and the success of knowledge transfer, and the differences that exist depending on the mode of cooperation. In Spain results show that an adequate, timely, complete, and credible communication in the university-industry relationship is positively related to the success of knowledge transfer. Results also evidence a higher correlation between communication behavior and successful knowledge transfer in the mode of cooperative research. Consequently, managers and researchers in cooperation agreements should pay special attention to inter- and intra-organizational communication.

Keywords: knowledge transfer; technology cooperation; research and development contract; cooperative research; university-industry relationship; networks; Spain.

Submitted: April 25th 2016 / Approved: September 11th 2016

Introducción

La transferencia de conocimiento tecnológico a la actividad económica se ha convertido en cuestión prioritaria en muchas agendas políticas (Debackere y Veugelers, 2005; Silveira, García y González, 2016). En este sentido, la literatura enfatiza la importancia que se concede a la información obtenida por los integrantes de la triple hélice (gobierno, industria y universidades) (Luengo y Obeso, 2013). Así, la esencia de la triple hélice radica en el papel del conocimiento en la sociedad y de la universidad en la economía (Etzkowitz, 2002). Concretamente se plantean las relaciones entre universidad, empresa y gobierno como forma de abordar la estrategia de desarrollo de una región o un país, enfatizando la transferencia de tecnología.

En los acuerdos de cooperación tecnológica que se establecen entre la empresa y la universidad existe un interés por ambas partes en compartir habilidades y recursos, lo que origina beneficios recíprocos (Muscio, 2010). En ello radica el incentivo para cooperar, ya que de esta forma cada parte implicada puede suplir sus limitaciones mediante el aprendizaje de habilidades y capacidades de la otra (Miotti y Sachwald, 2003). A través de la cooperación con la universidad, la empresa puede acceder a sus recursos tecnológicos e instalaciones (Santoro y Chakrabarti, 2002), lo que le permite complementar sus activos e incrementar su potencial en este campo. No obstante, dado que universidad y empresa poseen distintas misiones y modos de trabajar puede surgir una divergencia de intereses (Azevedo Ferreira y Rezende Ramos, 2015).

Este estudio analiza la transferencia de conocimiento entre la empresa y la universidad, proceso cuya importancia estratégica para la competencia de la empresa y para el crecimiento económico y social ha sido ampliamente enfatizado (Althoff Philippi *et al*., 2015; Morales Rubiano *et al*., 2015). De modo específico, la principal contribución de la presente investigación pone de manifiesto la influencia que el comportamiento de comunicación ejerce en la cooperación tecnológica entre empresa y universidad bajo un enfoque de redes. En este sentido, se plantean dos objetivos a alcanzar: (1) analizar cómo el comportamiento de comunicación se relaciona con la transferencia de conocimiento y (2) estudiar si el comportamiento de comunicación ejerce una influencia distinta en función de la modalidad bajo la que se desarrolla la relación.

El trabajo se organiza del siguiente modo: tras esta introducción, se exponen los fundamentos teóricos que lo sustentan, presentando las cuestiones de investigación y las hipótesis a contrastar; a continuación se plantea la metodología seguida y se describe el contexto de la

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ISSN: 0718-2724. (http://jotmi.org)

investigación, la muestra y las medidas utilizadas; seguidamente se presentan los resultados y, por último, se exponen las principales conclusiones así como las recomendaciones para futuras investigaciones.

Fundamentación teórica

La cooperación tecnológica entre la universidad y la empresa

En los negocios que se desarrollan en un escenario de colaboración, la red se percibe como una pieza clave desde la que los diferentes actores desarrollan su actividad mutua (Eriksson y Chetty, 2003; Vasilchenko y Morrish; 2011). Las actividades en la red permiten a las partes integrantes de la misma mantener relaciones de negocio, que a menudo se caracterizan por la confianza, la adaptación mutua de los recursos a lo largo del tiempo y las expectativas con respecto al comportamiento futuro de las partes (Forsgren, Holm y Johanson, 2007; Kontinen y Ojala, 2011). En este contexto, para conseguir ser eficientes, los directivos han de coordinar la interacción de los diferentes actores de la red de negocio (Forsgren, Holm y Johanson, 2007; Hohental, Johanson y Johanson, 2014) y comprender que las capacidades de su organización son limitadas, aunque pueden ser completadas y complementadas a través de la colaboración con otras empresas de la red (Madhok, 1996; Rialp, Galván-Sánchez y García, 2012). La posición de una organización en la red es importante, porque le concede la posibilidad de acceder a los recursos internos de otras organizaciones y a otros mercados (Johanson y Mattson, 1988; Gilmore *et al*., 2006; Zhou, Wu y Luo, 2007). Las redes son para las organizaciones el medio por el cual pueden acceder a fuentes de información externa, que son necesarias para involucrarse en nuevos mercados. Además, con la colaboración de los miembros de la red, se pueden llegar a compartir los riesgos (Kaufmann, 1995; Sharma y Blomstermo, 2003; Zain y Ng, 2006). Otros motivos por los que la organización puede desear establecer relaciones con socios son la búsqueda de nuevos mercados o clientes, el acceso al conocimiento, o el incremento de sus beneficios o ingresos (Holmlund y Kock, 1998; Hohental, Johanson y Johanson, 2014).

Por otra parte, diversos autores han establecido que las organizaciones buscan de sus socios aquellos recursos y capacidades tecnológicas de los que carecen, maximizando el valor empresarial a través de la combinación efectiva de los recursos del socio y explotando las complementariedades (Santamaría Sánchez y Rialp Criado, 2007). Así, las redes favorecen que en su seno se produzca la generación y la difusión de conocimientos e innovación (Ahrweiler, Pyka y Gilbert, 2011), necesarias para la competitividad de la organización. De forma específica, los acuerdos en tecnología surgen debido a la imposibilidad que manifiesta una empresa para generar internamente toda la tecnología que precisa (Guerras Martín, Montoro Sánchez y Mora Valentín, 2003). De hecho, todos los acuerdos en investigación y desarrollo (I+D) son, al menos para uno de los socios, formas de adquisición externa de tecnología.

Con la cooperación en I+D, las empresas tratan de optimizar unos recursos cada vez más necesarios para mejorar su competitividad (Benavides Velasco, 1998). El establecimiento de acuerdos de cooperación en I+D, mediante la subcontratación de tareas específicas o a través de la colaboración con otras organizaciones, constituye un importante mecanismo para lograr el dominio de tecnologías complejas (Nieto Antolín, 1998) y para estar en la vanguardia de los últimos avances tecnológicos (Hagedoorn, Link y Vonortas, 2000). Esta cooperación permite acelerar los procesos de investigación y desarrollo, al posibilitar la combinación de las capacidades especializadas de distintas organizaciones. En este sentido, un cierto grado de divergencia en las capacidades de las partes se convierte en un elemento clave para establecer acuerdos de cooperación en I+D (Petruzelli, 2011). Asimismo, el establecimiento de acuerdos de cooperación en materia de tecnología puede ser una vía para la transmisión de conocimientos y activos estratégicos pues, debido a que estos recursos se basan en habilidades y rutinas organizativas, son difíciles de imitar y transferir, por lo que su transferencia en el mercado puede ser complicada (Freeman *et al*., 2006).

Dentro de este tipo de acuerdos en tecnología se enmarca la cooperación que se establece entre la universidad y la empresa. En este sentido, como argumenta Quélin (2000), cuando se fomentan las relaciones con la universidad y otros centros de investigación se crea un entorno que se nutre de nuevas competencias. Así, según Perkmann, Neely y Walsh (2011), cuatro son los motivos por los que las empresas cooperan con las universidades: el deseo de acceder a financiación gubernamental, a menudo reservada a empresas que colaboran con las universidades; el interés por tener acceso a conocimiento básico científico; el deseo de mejorar su capacidad de resolución de problemas a través de la asistencia y asesoramiento de universidades en programas de investigación, y la posibilidad de alcanzar beneficios adicionales más allá de los que se logran con la alianza como puede ser una mejor reputación, el acceso a redes, etc.

Las universidades buscan en la colaboración con la empresa un acercamiento a la industria y la toma de contacto con problemas prácticos (Santoro, 2000). En ocasiones, el establecimiento de relaciones con la empresa obedece, además, a la búsqueda de fondos para la financiación de los proyectos (Santoro, 2000; Barnes, Pashby y Gibbons, 2002), la adquisición y modernización de los laboratorios y equipos, y la recompensa del personal investigador (Nieto Antolín, 1998; Lee, 2000). Asimismo, la cooperación con la empresa abre una vía para la aplicación de los conocimientos generados en la universidad. En efecto, la cooperación entre la universidad y la empresa constituye una plataforma que permite la transferencia de tecnología entre ambas (Bruneel, D'Este y Salter, 2010; Lai, 2011). Por otra parte, y dado que la universidad es una institución al servicio de la sociedad, uno de los retos que se le plantea es la cooperación con las empresas. Así, se requiere que las universidades no sólo desempeñen un papel activo en la educación y en el desarrollo científico y tecnológico, sino que transformen, en la medida de lo posible, sus resultados científicos en innovaciones útiles para la empresa (Debackere y Veugelers, 2005; Perkmann, Neely y Walsh, 2011).

La cooperación tecnológica entre empresas y universidades puede revestir diversas modalidades atendiendo a distintos criterios (Santoro, 2000; Rogers, Takegami y Yin, 2001; Mora Valentín, 2002; Debackere y Veugelers, 2005). A partir de la distinción entre las modalidades

definidas como contratos de I+D e investigación cooperativa, cabe inferir importantes implicaciones normativas de cara a regular las actividades investigadoras universitarias (Nieto Antolín, 1998).

De esta forma, en el contrato de I+D la empresa encarga a la universidad la realización de un trabajo específico, definiendo desde el primer momento los términos en los que este debe llevarse a cabo y realizando una contraprestación a cambio (Mora Valentín, 2002). Es decir, la empresa subcontrata una investigación que se desarrolla en las instalaciones de la universidad según sus propias especificaciones y la universidad, a cambio, recibe una contraprestación (Nieto Antolín, 1998). En principio se entiende que la universidad no está directamente interesada en la investigación ni en sus resultados. De este modo, la cooperación entre la universidad y la empresa bajo la forma de contrato de I+D se encuadra en el marco de las alianzas verticales, estableciéndose una relación similar a la que existe entre un proveedor y su cliente y en la que la empresa demanda un servicio que le ofrece la universidad. Asimismo, los contratos de I+D se pueden calificar como acuerdos cerrados, o sin participación explícita de la empresa, ya que implican la transferencia de una tecnología existente o la subcontratación de su desarrollo, sin que exista una actividad conjunta entre las partes. En esta situación, la transferencia de tecnología se considera como una transacción de compraventa a precio de mercado que tiene lugar entre la universidad y la empresa (Liu y Jiang, 2001).

Por su parte, cuando la relación se desarrolla bajo la denominación de investigación cooperativa, la cooperación entre la universidad y la empresa se considera como un tipo de acuerdo horizontal complementario en el que las partes, que no son rivales directos, realizan una contribución de naturaleza diferente aunque complementaria (Nieto Antolín, 1998). En la investigación cooperativa la universidad y la empresa están interesadas en la misma línea de investigación y la contraprestación es el beneficio mutuo que ambas obtienen (Mora Valentín, 2002). En este tipo de acuerdo, la empresa se beneficiará de las actividades de investigación contratadas y, a cambio, proporcionará recursos económicos o de otro tipo al equipo investigador para realizar las tareas de investigación básica, aplicada o de desarrollo experimental. De esta forma, la investigación en cooperación constituye un acuerdo abierto o con participación explícita de la empresa pues necesariamente conlleva la realización de actividades por ambas partes. De acuerdo con Liu y Jiang (2001), desde esta perspectiva la transferencia de tecnología se conforma como una actividad de colaboración que tiene lugar en el marco de una red establecida, caracterizada por relaciones formales e informales.

En este contexto de cooperación tecnológica entre la empresa y la universidad, procede discutir la importancia que el comportamiento de comunicación ejerce en el resultado de la relación de cooperación y en la transferencia de conocimiento que se genera entre ambos agentes.

El comportamiento de comunicación en la cooperación tecnológica entre la universidad y la empresa

A lo largo del tiempo, la investigación empírica ha evidenciado la importancia del comportamiento de comunicación como factor crítico en los resultados organizativos, siendo un elemento esencial en un contexto de colaboración para alcanzar los beneficios de la cooperación entre la universidad y la empresa. Ante este contexto de interdependencia mutua, en el que las partes dependen una de otra para el acceso a recursos complementarios, es clara la motivación de los socios hacia el desarrollo de relaciones de calidad fundamentadas en una comunicación abierta y transparente, donde exista un intercambio de información frecuente y participativo (Morgan y Hunt, 1994; Sarkar *et al*., 2001). En este sentido, Cannon y Homburg (2001) destacan que un flujo abierto de información entre las partes facilita el conocimiento anticipado de los planes futuros, que hace posible que coordinen sus actividades. En esta línea, Yilmaz y Hunt (2001) señalan que compartir información de forma oportuna y precisa, a través de medios tanto formales como informales, permite a los participantes de la relación tener más confianza en sus atribuciones respecto a la honradez de los otros y, en consecuencia, favorece el comportamiento de cooperación. Así, por ejemplo, la implantación y la adopción exitosa de sistemas de información interorganizativos requiere la existencia de una estrecha relación entre las partes pues estarán motivadas a participar porque perciben que pueden lograr sus objetivos (Hunt *et al*., 2006).

Por otra parte, Mohr y Spekman (1994) destacan el papel clave que desempeña la calidad de la comunicación en la transmisión de información, entendida como el grado en que los integrantes de la red perciben que los flujos de comunicación son adecuados, oportunos (*i.e.*, se producen a tiempo), precisos, completos y creíbles. En un marco de relaciones de cooperación, la calidad de la comunicación se convierte en un indicador del resultado organizativo, de manera que una información oportuna, relevante y precisa es esencial para el logro de los objetivos. En este sentido, un elevado nivel de calidad de la comunicación se asocia con acuerdos más exitosos y satisfactorios con respecto a diversos aspectos de la relación tales como apoyo de la otra parte y trato personal, entre otros (Mohr y Spekman, 1994; Frasquet, Calderón y Cervera, 2012; Autores, 2013).

En el contexto de la relación que se establece entre la universidad y la empresa, una de las principales dificultades puede ser, precisamente, la comunicación. Es más, tal y como señala la literatura (*e.g.*, Plewa *et al.*, 2005; Plewa y Quester, 2007; Frasquet, Calderón y Cervera, 2012), la comunicación puede ser un aspecto más difícil de gestionar cuando se produce entre organizaciones procedentes de distintos entornos, debido, por ejemplo, a la divergencia de objetivos, culturas, etc. Según Rahil (1992), el *gap* de comunicación se puede deber al desconocimiento que tiene la empresa de la investigación que se realiza en la universidad, al bajo conocimiento que la universidad tiene de las necesidades de la industria y a la dificultad de ambas partes para mantenerse al corriente de los progresos de cada una. Para superar este déficit de comunicación en cuanto a calidad y cantidad, uno de los factores a tener en cuenta es la existencia de una interacción regular y directa entre la universidad y la empresa, tal y como sugieren Quélin (2000) y Mothe y Quélin (2000). En efecto, la ausencia de comunicación entre las partes puede constituir una fuente de inestabilidad del acuerdo de cooperación.

Dado que la transferencia de conocimiento tecnológico como la que se genera en un acuerdo de cooperación puede conceptualizarse como un

proceso de comunicación (Albino *et al.*, 2001), una vez comprometida en la transferencia de tecnología, la universidad (unidad emisora o fuente) deberá indagar las necesidades de la empresa (unidad receptora) y sus problemas con el fin de ser capaz de transferir los componentes adecuados del conocimiento requerido y prestar el apoyo necesario durante la etapa inicial de su utilización (Szulanski, 1996). El éxito de esto depende, hasta cierto punto, de la facilidad de la comunicación y de la intimidad de la relación. De hecho, en ocasiones, la naturaleza de la relación entre la unidad receptora y la emisora puede ser una barrera para la transferencia efectiva de conocimiento (Goh, 2002). Si la relación entre ambas es distante o la comunicación es difícil, es menos probable que se produzca la transferencia. Con respecto a la comunicación que se establece entre el emisor y el receptor, es necesario distinguir el nivel de intercambio de información atendiendo al grado en que se comunica la información crítica a la otra parte, así como la calidad con la que se desarrolla el proceso de comunicación. Así, una comunicación fluida y eficiente facilita la transferencia de conocimiento entre las partes implicadas (Sherwood y Covin, 2008; Frasquet *et al.*, 2012). A su vez, una comunicación frecuente es importante para el éxito de los acuerdos de cooperación tanto para los que implican conocimiento tácito como explícito (Niedergassel y Leker, 2011). De modo específico, el grado y la calidad de la comunicación son especialmente relevantes cuando el conocimiento a transferir es fundamentalmente tácito, pues su adecuada transferencia requiere de una mayor interacción entre la fuente y el receptor, así como de la utilización de mecanismos que se caracterizan por una mayor riqueza de comunicación (Santoro y Bierly, 2006).

Tras la revisión de la literatura llevada a cabo y considerando los objetivos del trabajo, se plantea analizar en primer lugar cómo el comportamiento de comunicación se relaciona con la transferencia de conocimiento en el contexto de los acuerdos de cooperación entre la empresa y la universidad, proponiendo para ello la siguiente hipótesis de investigación:

H1: El comportamiento de comunicación está positivamente relacionado con el éxito de la transferencia de conocimiento desde la universidad a la empresa.

Asimismo se pretende determinar la existencia de diferencias en cuanto a la relación que existe entre el comportamiento de comunicación y el éxito de la transferencia de conocimiento, atendiendo al tipo de relación que se establece entre el receptor y el emisor. En este sentido, cabría esperar que, dado que los acuerdos desarrollados bajo la forma de investigación cooperativa implican una mayor interacción entre la empresa y la universidad, el comportamiento de comunicación guarde en los mismos una mayor relación con el éxito de la transferencia de conocimiento. A partir de aquí se formula la siguiente hipótesis de investigación:

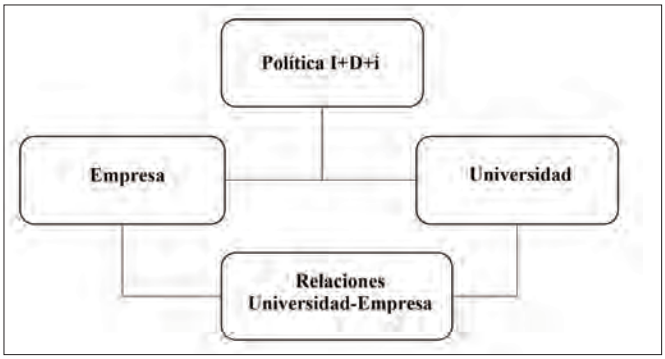
H2: El comportamiento de comunicación se relaciona con más intensidad con el éxito de la transferencia de conocimiento cuando la relación entre la empresa y la universidad se desarrolla bajo la forma de investigación cooperativa que de contrato de I+D.

Metodología

Contexto de la investigación, población y muestra

El presente trabajo se desarrolla en el contexto de la cooperación tecnológica entre empresa y universidad en España. La transferencia de los conocimientos generados en la universidad y su presencia en el proceso de innovación del sistema productivo y de las empresas se articula, en este país, a través de cuatro elementos clave: la política científica y tecnológica del Gobierno estatal (política de Investigación, Desarrollo e Innovación Tecnológica [I+D+i]), la empresa, la universidad y las relaciones que se establecen entre ambas (véase figura 1).

Figura 1. Elementos del contexto de la investigación



Dada la importancia de las relaciones entre la empresa y la universidad para mejorar la competitividad del tejido productivo del país, existen políticas públicas encaminadas al fomento de las mismas. Concretamente, las políticas de I+D+i son competencia del Ministerio de Economía y Competitividad del Estado, siendo su instrumento fundamental el Plan Nacional de I+D+i. Desde la aprobación del primer Plan Nacional en 1988 la capacidad del sistema público de I+D+i se ha incrementado, fortaleciendo considerablemente el Sistema Español de Ciencia, Tecnología e Innovación (SECTI), integrado por el conjunto de agentes públicos y privados implicados en la promoción y el desarrollo de la política de I+D+i en España.

En los distintos planes nacionales se recogen acciones orientadas al apoyo a la innovación y la transferencia de tecnología entre las empresas y los centros públicos de investigación. Con dichas acciones se pretende rentabilizar las actuaciones financiadas a través de los Presupuestos Generales del Estado, al estimular que los resultados de las actividades de I+D+i llevadas a cabo por el sector público puedan resolver necesidades del sector empresarial. Así, en el Plan Nacional vigente (2013-2016) se recoge un subprograma de fomento de la I+D+i colaborativa orientada a las demandas de las empresas. Los objetivos de las actividades de I+D+i desarrolladas en el marco de este subprograma se centran en la promoción de la colaboración entre los agentes del SECTI para facilitar la orientación de la investigación a las necesidades a medio y largo plazo del tejido productivo. Entre los centros públicos de investigación que pueden participar en este subprograma se encuentran las universidades. De forma más específica, en España las relaciones que se generan entre la universidad y la empresa se canalizan fundamentalmente a través de las fundaciones universitarias y de las oficinas de transferencia de resultados de investigación.

En este contexto se realizó un trabajo de campo de ámbito nacional con el fin de contrastar las hipótesis propuestas. La población a analizar en el estudio estaba conformada por proyectos de cooperación tecnológica, finalizados en un periodo de tres años en los que se haya producido una transferencia de tecnología entre un equipo de investigación perteneciente a una universidad pública española y una empresa radicada en España. Se incluyeron los acuerdos de investigación y desarrollo tecnológico, pero no aquellos que tienen como objeto la asistencia técnica, el asesoramiento o la formación. Con estas condiciones de referencia, al tratar de cuantificar la población objeto de estudio se presentó el problema de la inexistencia de una base de datos en la que figuraran los acuerdos con las características impuestas. A pesar de esta importante limitación y en aras de conformar una muestra representativa se acometieron diversas acciones. En primer lugar, se realizó la presentación del proyecto de investigación en la reunión anual de la Red Española de Fundaciones Universidad-Empresa, al objeto de solicitar su colaboración. Seguidamente se realizó una búsqueda de investigadores participantes en acuerdos con empresas, consultándose las memorias de las universidades disponibles en Internet y, en particular, las tareas investigadoras de los departamentos de corte técnico. El tercer paso consistió en la localización de investigadores adscritos a departamentos con las características apuntadas, pertenecientes a universidades para las que no se pudo consultar la memoria de investigación. Finalmente se llevó a cabo una búsqueda en Intern*et al* objeto de detectar empresas potencialmente participantes en acuerdos con las características descritas. En cualquier caso, tras acceder a una de las partes implicadas en el acuerdo, el siguiente paso era siempre tratar de contactar con la otra parte, a través de la información que había suministrado la primera. El informante clave, y a quien se dirigía el cuestionario, era el responsable del acuerdo por parte de la empresa. El trabajo de campo de la encuesta se realizó durante cuatro meses, obteniéndose finalmente una muestra integrada por 87 acuerdos, lo que supuso un error muestral del 10,7%, bajo la consideración, de seguro sobreestimada, de que la población objeto de estudio es infinita.

Variables empleadas

Comportamiento de comunicación entre el emisor y el receptor

Con el fin de determinar el tipo de relación que se estableció entre la empresa y el investigador, así como la fluidez de la comunicación entre ambos, se midió la calidad de la comunicación y el grado de intercambio de información atendiendo al planteamiento de Mohr y Spekman (1994). De este modo, se planteó una escala multidimensional con doce ítems con fundamentación en las propuestas por Rahil (1992), Mohr y Spekman (1994) y Szulanski (1996).

Éxito de la transferencia de conocimiento

Con el fin de recabar la percepción de la empresa en relación con el conocimiento absorbido por ella se plantearon siete afirmaciones con las que el encuestado tenía que señalar su grado de acuerdo en una escala Likert de 7 puntos. La escala utilizada se basó en la propuesta por Simonin (1999), añadiendo una afirmación adicional que permitiera saber si el conocimiento absorbido por la empresa había sido aplicado a sus procesos internos o a fines comerciales. Además, se incluyeron cuatro afirmaciones adicionales a fin de determinar la satisfacción experimentada por la empresa con el acuerdo de colaboración, dado que se observó que, en la mayor parte de los trabajos sobre relaciones interorganizativas, esta se considera una medida aceptable del logro de los objetivos.

Tipo de acuerdo

Para identificar la modalidad de cooperación tecnológica, se redactó una pregunta con la que se pretendía clasificar la relación mantenida entre empresa e investigador en uno de los dos tipos de acuerdos que se habían definido a partir de García Canal (1995) y Santamaria Sánchez (2001).

Con respecto a las técnicas estadísticas empleadas, se ha de señalar que, una vez concluido el trabajo de campo y tras depurar la base de datos, se procedió a analizar la fiabilidad y la validez de las escalas de medida. Seguidamente, al objeto de reducir su dimensionalidad y facilitar el análisis y la interpretación de los datos con la menor pérdida de información posible, se planteó la aplicación de un análisis de componentes principales con rotación varimax. Por último, y en aras de contrastar las hipótesis planteadas, se utilizó como herramienta estadística el coeficiente de correlación de Pearson.

Análisis de resultados

Fruto de la aplicación del análisis de componentes para la escala que mide el éxito de la transferencia de conocimiento, se han obtenido dos factores que retienen cerca del 80% de la varianza total (véase Tabla 1). El primer factor explica el 50,9% de la variabilidad total y aglutina los ítems relativos a la satisfacción que el receptor (empresa) ha experimentado en su relación con el emisor (universidad) valorando aspectos como su intención de volver a cooperar con el mismo. El segundo factor se refiere a la asimilación y posterior aplicación que el receptor ha hecho del conocimiento transferido. Ambas dimensiones miden conjuntamente el éxito de la transferencia de conocimiento que ha tenido lugar durante la relación establecida entre el emisor y el receptor.

Tabla 1. Análisis de componentes principales y grado de fiabilidad de la escala que mide el éxito de la transferencia de conocimiento

Factores	Ítems	Com.	C. F.	% Var. Exp.	% Acum. var. exp.	Alfa de Cronbach
Satisfacción con la relación	Intención de colaboración futura con equipo de investigación	0,905	0,930	50,9	50,9	0,9173
	Intención de colaboración futura con centro de investigación	0,868	0,919			
	Satisfacción con resultados	0,817	0,816			
	Satisfacción con resultados relación precio/calidad	0,653	0,758			
	Aprendizaje sobre conocimiento	0,700	0,693			
Asimilación y aplicación del conocimiento	Aplicación de conocimiento a procesos internos y/o a fines comerciales	0,830	0,891	29,0	79,9	0,7946
	Asimilación de conocimiento	0,818	0,849			
Índice KMO: 0,870 Prueba de esfericidad de Bartlett: 452,35 (0,000)						0,9011

Com.= comunalidad C. F.= carga factorial

Los resultados de la Tabla 2 permiten valorar la fiabilidad de la escala que evalúa el comportamiento de comunicación entre el emisor y el receptor, que, como se puede apreciar, resulta excelente. El análisis realizado sintetiza la dimensión de la escala en dos factores, que se corresponden con los identificados en el marco teórico. En primer lugar, explicando cerca de un 50% de la varianza, se sitúa el factor que se ha denominado calidad de la comunicación. Dicho factor, además de valorar la comunicación entre el emisor y el receptor, también incorpora cuestiones relativas a la comunicación intraorganizativa, es decir, entre los miembros de las unidades emisora y receptora. No obstante, es preciso señalar que los ítems correspondientes al primer aspecto (*i.e.,* comunicación interorganizativa) son los que presentan mayor carga factorial en el mismo. El segundo factor mide un aspecto concreto de la relación que se establece entre los agentes y es el grado en que se produce el intercambio de información. Con la adición de dicho factor se logra explicar el 75,4% de la variabilidad total.

Tabla 2. Análisis de componentes principales y grado de fiabilidad de la escala que mide el comportamiento de comunicación

Factores	Ítems	Com.	C. F.	% Var. Exp.	% Acum. var. exp.	Alfa de Cronbach
Calidad de la comunicación	Comunicación adecuada	0,876	0,910	44,7	44,7	0,9302
	Comunicación fácil	0,824	0,877			
	Comunicación oportuna	0,795	0,866			
	Comunicación completa	0,824	0,861			
	Comunicación entre empresa y universidad	0,733	0,846			
	Comunicación creíble	0,751	0,785			
	Comunicación entre miembros del equipo de investigación	0,454	0,662			
	Comunicación entre miembros de la empresa	0,516	0,558			
Grado de intercambio de información	Información de acontecimiento	0,946	0,949	30,7	75,4	0,9196
	Información de cambio de necesidades	0,938	0,946			
	Información solicitada	0,759	0,850			
	Información de ayuda	0,634	0,755			
Índice KMO: 0,836 Prueba de esfericidad de Bartlett: 1.203,87 (0,000)						0,9246

Com.= comunalidad C. F.= carga factorial

Una vez reducida la dimensión de las escalas, se procedió a contrastar la primera hipótesis planteada (véase Tabla 3). Como se puede apreciar, la dimensión relativa a la calidad de la comunicación mantiene una relación positiva y significativa tanto con la satisfacción que experimenta el receptor como con la asimilación y aplicación que este realiza del conocimiento, si bien la relación es más fuerte con la primera dimensión que mide el éxito de la transferencia. En cambio, el grado de intercambio de información no parece guardar ninguna relación con ninguna de las dimensiones que miden el éxito de la transferencia, si bien tampoco se detecta ninguna influencia negativa que sea significativa. Ante esto se acepta de manera parcial la primera hipótesis planteada, teniendo en cuenta las matizaciones realizadas.

Tabla 3. Grado de asociación entre el comportamiento de comunicación y el éxito de la transferencia de conocimiento

	Satisfacción con la relación	Asimilación y aplicación de conocimiento
Calidad de la comunicación	r= 0,785 (0,000)	r= 0,262 (0,015)
Grado de intercambio de información	NS	NS

NS = no significativo

Con el fin de responder a la segunda cuestión de investigación planteada se dividió la muestra en dos submuestras (véase Tabla 4). Como se aprecia, un 71,3% de los acuerdos se desarrollan bajo el modo identificado como investigación cooperativa, es decir, se trata de una forma de colaboración en la que en todo momento los empleados de la empresa y los miembros del equipo investigador por parte de la universidad trabajan conjuntamente para la obtención de un objetivo. Por contra, un 28,7% se desarrolló como un contrato de I+D.

Tabla 4. Tipo de acuerdo

	Frecuencia	Porcentaje
Contrato de I+D	25	28,7
Investigación cooperativa	62	71,3
TOTAL	87	100,0

A partir de la identificación de las dos submuestras se intentará determinar para cada una de las mismas el grado de asociación que existe entre los factores del comportamiento de comunicación y el éxito de la transferencia (véase Tabla 5). Con respecto a los acuerdos desarrollados bajo la modalidad de investigación cooperativa, se observa que ambas dimensiones del comportamiento de comunicación se asocian positivamente con la satisfacción que experimenta la empresa. A su vez, la calidad de la comunicación se relaciona con la dimensión del éxito de la transferencia de conocimiento que mide la asimilación y aplicación de conocimiento. Sin embargo, en el caso de los contratos de I+D solo se observa una asociación positiva entre la dimensión de la calidad de la comunicación y la satisfacción de la empresa con la relación. Antes estas evidencias, se procede a aceptar la segunda hipótesis de investigación que establecía que el comportamiento de comunicación se relaciona con más intensidad con el éxito de la transferencia de conocimiento en la modalidad de investigación cooperativa que en la de contrato de I+D.

Tabla 5. Grado de asociación entre el comportamiento de comunicación y el éxito de la transferencia de conocimiento por tipo de acuerdo

	Satisfacciócon la relación		Asimilación y aplicación de conocimiento	
	Contrato de I+D	Investigación cooperativa	Contrato de I+D	Investigación cooperativa
Calidad de la comunicación	r= 0,833 (0,000)	r= 0,765 (0,000)	NS	r= 0,376 (0,003)
Grado de intercambio de información	NS	r= 0,268 (0,037)	NS	NS

Conclusiones

Este trabajo estudia la importancia del comportamiento de comunicación en la cooperación tecnológica entre empresa y universidad, bajo el enfoque de redes. Dos son los objetivos que se han perseguido. En primer lugar, se analiza la relación entre el comportamiento de comunicación y la transferencia de conocimiento. En segundo lugar, se estudia si el comportamiento de comunicación ejerce una influencia distinta en función de la modalidad bajo la que se desarrolla la relación.

Con base en los resultados obtenidos es posible afirmar que el comportamiento de comunicación se relaciona de forma positiva con el éxito de la transferencia de conocimiento. En particular, la dimensión que mide la calidad de la comunicación, y que valora tanto aspectos de la comunicación intraorganizativa como inteorganizativa, mantiene una relación positiva con la satisfacción que experimenta la empresa con la relación, confirmando los resultados obtenidos por Frasquet *et al.* (2012). En otras palabras, una comunicación adecuada, oportuna, completa y creíble entre los miembros de la empresa y del equipo de investigación universitario se asocia positivamente con la satisfacción de la empresa con los resultados de la relación, su intención de colaboración futura y su nivel de aprendizaje. Asimismo, la calidad de la comunicación también guarda una asociación positiva con la dimensión del éxito de la transferencia que mide la asimilación y aplicación de conocimiento. Por el contrario, no se detecta asociación directa entre el grado de intercambio de información y el éxito de la transferencia de conocimiento. Por ejemplo, no se constata que exista una relación directa entre el hecho de que se informe al equipo de investigación de cualquier acontecimiento o cambio que pudiera afectarle y la satisfacción que experimenta la empresa con la relación, así como la asimilación y aplicación que hace del conocimiento transferido. Ello puede deberse a que quizá la asociación de estas variables esté mediada por algún otro factor como pueda ser la calidad de la relación, entendida como el grado de confianza y compromiso organizativo entre las partes.

Del mismo modo se observan diferencias en cuanto a la relación que existe entre el comportamiento de comunicación y el éxito de la transferencia de comunicación atendiendo al modo en que se desarrolla la relación entre la empresa y la universidad. Así, se observa que, de acuerdo con la hipótesis propuesta, existe una mayor asociación entre el comportamiento de comunicación y el éxito de la transferencia de conocimiento cuando el acuerdo se desarrolla bajo la forma de investigación cooperativa que cuando tiene lugar bajo la modalidad de contrato de I+D. Ello puede obedecer a que la investigación cooperativa requiere un mayor nivel de interacción entre la universidad y la empresa y, en consecuencia, puede generarse un mayor grado de satisfacción con la relación, y de asimilación y aplicación del conocimiento.

En general, del trabajo se deriva una serie de implicaciones para la práctica directiva. Por una parte, se pone de manifiesto la necesidad de que los directivos participantes en acuerdos de cooperación con la universidad presten especial atención a la comunicación tanto intraorganizativa como interorganizativa dada su incidencia en el éxito de la transferencia de conocimiento, especialmente en la satisfacción que las partes experimentan con la relación. Esta recomendación cobra aún más relevancia en el contexto de los acuerdos que se desarrollan bajo la modalidad de investigación cooperativa, en la que necesariamente ambas partes realizan actividades. Asimismo, se hace necesario trasladar la importancia de enfatizar el comportamiento de comunicación a los investigadores universitarios que pretendan mejorar los resultados de los acuerdos de cooperación en los que se impliquen.

Por otra parte, la universidad debe tomar conciencia de su excesiva burocratización porque puede suponer una barrera a la colaboración con la empresa, que suele ser más flexible y estar más capacitada para adaptarse a los cambios. Además, como apuntan Frasquet *et al.* (2012), la universidad debería estudiar las necesidades de las empresas con el fin de poder facilitarles bienes y servicios que cubran dichas necesidades. Ello estaría en concordancia con la filosofía de las políticas públicas de fomento de la I+D+i orientadas a satisfacer las demandas del tejido productivo y recogidas en el Plan Nacional de I+D+i.

A pesar de estas contribuciones, se ha de señalar que los resultados empíricos se han obtenido de manera exploratoria. Así, no se ha contemplado la interacción que el comportamiento de comunicación puede tener con otras variables potencialmente determinantes del éxito de la transferencia de conocimiento, lo cual sería conveniente de cara a profundizar en su poder explicativo. Se ha incidido en el estudio de la transferencia de conocimiento desde la universidad a la empresa. No obstante, esta transferencia es bidireccional, por lo que sería deseable en el futuro abordar el estudio de la misma contemplando este hecho. Por otra parte, también se hace necesario considerar las limitaciones asociadas al instrumento de medida.

Adicionalmente, de cara a futuros trabajos, sería deseable replicar la investigación en otros contextos en los que se produzca una transferencia de conocimiento. A su vez, sería conveniente incrementar la muestra al objeto de ahondar en las posibles diferencias que existen con respecto a la relación que el comportamiento de comunicación guarda con el éxito de la transferencia de conocimiento atendiendo a la modalidad bajo la que se desarrolla la relación. Por último, se debería seguir profundizando en la relación que existe entre el intercambio de información y el éxito de la transferencia de conocimiento, al objeto de indagar en la posible existencia de variables mediadoras.

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ISSN: 0718-2724. (http://jotmi.org)

Impacto de los obstáculos al conocimiento en la innovación de las empresas chilenas *

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Resumen: La literatura sobre obstáculos a la innovación se ha centrado principalmente en las restricciones financieras. En esta investigación, utilizando la 8° Encuesta de Innovación en Empresas, analizamos el impacto de los obstáculos de conocimiento en la probabilidad de innovar. Nuestros resultados muestran que, al corregir por la endogeneidad de los obstáculos, éstos reducen la probabilidad de innovar en las firmas chilenas. Además, el impacto es negativo tanto para innovaciones tecnológicas como no tecnológicas. Nuestros resultados tienen importantes implicancias de política, sugiriendo que las políticas no solo se deben centrar en las restricciones financieras, sino que también en obstáculos de conocimiento como la disponibilidad de recursos humanos y la información sobre mercados y nuevas tecnologías.

Palabras clave: Innovación; conocimiento; obstáculos.

Abstract: Title: *Impact of Knowledge Obstacles on Chilean Firms´s Innovation*.
Most of previous literature about innovation obstacles has focused on the impact financial constraints. In this paper, using the 8th Chilean Innovation Survey, we analyze the impact of knowledge obstacles on the probability of introducing innovations. Our results show that, dealing with endogeneity of the obstacles, these reduce the innovation probability in the Chilean firms. This impact is negative for both technological and non-technological innovations. Our findings have relevant policy implications, suggesting that policies not only have to be focused on financial constraints, but also on knowledge barriers such as availability of human resource and information about markets and new technologies

Keywords: innovation, knowledge, obstacles.

Submitted: May 5th 2017 / Approved: September 8th 2017

1. Introducción

La innovación es uno de los factores más relevantes para la productividad y el crecimiento económico (Schumpeter, 1934), no sólo para países desarrollados sino también para los países en desarrollo (Crespi & Zúñiga, 2012; Lee & Kang, 2007). Es por ello que estudiar los factores que inhiben la innovación en las empresas es importante, ya que permitiría enfocar políticas a mitigar el impacto de estos factores y así aumentar los niveles de innovación y productividad de los países. Si bien el fenómeno de la innovación ha sido bastante estudiado, tanto a nivel agregado como a nivel de firmas, la relevancia e impacto de los obstáculos es un tema relativamente reciente.

Esta literatura, sin embargo, se ha centrado principalmente en los efectos de los obstáculos financieros (Schneider et al., 2010; Blanchard et al., 2013; Pellegrino & Savona, 2017), incluyendo trabajos que han estimado efectos heterogéneos por sector productivo (Hottenrott & Peters, 2012) y por tamaño de empresas y tipo de innovación (Álvarez & Crespi, 2015).

Uno de los aportes más relevantes en esta área han sido los trabajos de Savignac (2008) y Pellegrino y Savona (2017), quienes han identificado los problemas asociados al sesgo de selección y endogeneidad cuando se intenta estimar el impacto causal de los obstáculos sobre la innovación. Cuando se incluye a todas las firmas en la estimación, se encuentra una relación positiva entre obstáculo e innovación. Esto se explica porque se incluyen firmas que no innovan y declaran no enfrentar ningún obstáculo. Ambos trabajos muestran que restringiendo la muestra a firmas potencialmente innovadoras, las estimaciones revelan una relación negativa entre obstáculo e innovación. Además, Savignac (2008) muestra que, luego de corregir por endogeneidad, la relación se hace incluso más negativa.

En los últimos años se han ido desarrollando estudios que intentan dilucidar la importancia de otros obstáculos, ya sean obstáculos de conocimiento, de mercado o de políticas (Pellegrino & Savona, 2017; Blanchard et al., 2013; D'Este, Rentocchini & Vega-Jurado, 2014). Por ejemplo, Pellegrino & Savona (2017) utilizan datos para el Reino Unido y encuentran que factores relacionados a la demanda y al mercado de las innovaciones son tan importantes como factores financieros para disminuir la innovación. Blanchard, et al. (2013) distinguen entre obstáculos financieros y no financieros y encuentran que ambos juegan un papel significativo en disminuir la innovación de las empresas; D'Este, et al. (2014) se centran en estudiar la complementariedad del capital humano y los obstáculos a la innovación, tanto financieros como no financieros. En el caso de Chile, Bravo (2016) explora el rol de los obstáculos de demanda y encuentra que éstos reducen la probabilidad de actividades de innovación en 17%.

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*Este trabajo es parte de la Tesis de Magister en Análisis Económico de la Universidad de Chile. Agradecemos los comentarios y sugerencias de Álvaro García, Jaime Ruiz-Tagle, Rodrigo Wagner, Juan Pablo Torres y de los asistentes a los seminarios de investigación de la Facultad de Economía y Negocios de la Universidad de Chile. Alvarez agradece la hospitalidad de la División de Competitividad e Innovación del Banco Interamericano del Desarrollo, donde realizó parte de esta investigación.

Esta investigación contribuye a la literatura de obstáculos a la innovación, analizando el impacto de los obstáculos de conocimiento sobre la innovación en las empresas. Para ello, se utilizan datos de la Octava Encuesta de Innovación en Empresas en Chile, que cuenta con información sobre las características generales de las empresas y sobre las actividades de innovación. El motivo de focalizar el análisis de los obstáculos de conocimiento, y no otros obstáculos, es que en primer lugar éste no ha sido estudiado por sí solo. Una contribución adicional es generar evidencia empírica en una economía emergente en un área donde los trabajos son mayoritariamente realizados en países desarrollados.

El presente trabajo continúa en la sección II con el marco teórico de la investigación. En la sección III se presentan los datos. Luego, en la sección IV se revisa la estrategia empírica. En la sección V, se muestran los resultados. En la sección VI, se resumen las conclusiones.

2. Marco Teórico

En esta investigación se analiza el efecto que tienen los obstáculos de conocimiento sobre la innovación en las firmas, por lo tanto necesitamos entender cómo el conocimiento puede afectar las decisiones de innovación. Una primera aproximación considera la firma como un ente creador de conocimiento, donde la habilidad de crear y utilizar dicho conocimiento es la fuente más importante de ventajas competitivas sostenibles para las firmas. Esta visión de la firma es conocida en la literatura como knowledge-based view (Nonaka, 1994; Grant, 1996; Nonaka et al., 2000). Según esta visión, el manejo del conocimiento es tan importante como el manejo de otros aspectos como el marketing y las finanzas (Leonard-Barton, 1995). El conocimiento se considera uno de los recursos más relevantes y que por ende debe ser correctamente administrado para obtener su máximo potencial.

El conocimiento se relaciona positivamente con la innovación en las empresas. Sin embargo, afecta a las firmas de manera diferente. Si consideramos a la innovación como un proceso donde intervienen muchos factores, el conocimiento es un insumo para la innovación, pero es un factor que puede ser más relevante en ciertos casos que en otros. En particular, es esperable que el efecto que tenga el conocimiento sobre la innovación dependa del proyecto que está realizando la firma. Por ejemplo, si las innovaciones tecnológicas son más intensivas en conocimiento que las innovaciones no tecnológicas, entonces el impacto del conocimiento sería mayor sobre la probabilidad de introducir innovaciones tecnológicas. Lo mismo si se refiere a innovaciones más radicales o disruptivas.

Además se debe tener en cuenta que otros factores que afectan la innovación, como por ejemplo el tamaño de una firma y/o si es exportadora o no, pueden capturar el efecto del conocimiento. Si bien existe evidencia empírica que respalda el hecho de que firmas más grandes y/o exportadoras innoven más, esto puede deberse a que se encuentran menos restringidas, ya sea en términos de conocimiento o financiamiento. Por ello, considerar estas barreras es importante para entender el efecto de otros determinantes de la innovación.

En términos simples, suponga que la decisión de realizar un cierto tipo de innovación j está dado por la comparación entre la inversión (I) que se necesita para llevar a cabo la innovación y el valor presente neto de los beneficios esperados (π) de tal innovación. La inversión se realiza sólo si:

$$\pi_j (X, C) \geq I_j (C) \qquad (1)$$

En este caso, siguiendo la discusión anterior, el grado de conocimiento (C) puede aumentar los beneficios de la innovación, ya sea por un mayor conocimiento de mercado de los nuevos productos o por acceso a mejores tecnologías, o porque reduce los costos de la inversión. Los beneficios son también afectados por otras características de las firmas denotadas por X, que reflejan, entre otras cosas, su acceso a los mercados internacionales, tamaño y propiedad.

Esta simple formulación del problema de decisión de las firmas permite ilustrar la endogeneidad de C y el tipo de proyectos de innovación que realiza la firma. Asuma que la firma tiene j=1….a J proyectos disponibles, que requieren un nivel de conocimiento C_j. En tal caso, simplificando al caso de elegir un proyecto, una firma que maximiza beneficios escogerá el proyecto j tal que:

$$\pi_j (X, C_j) \geq I (C_j) \qquad (2)$$

y

$$\Delta_j > \Delta_k \quad \text{para todo } k \neq j \qquad (3)$$

con

$$\Delta_j = \pi_j (X, C_j) - I (C_j)$$

De (2) debiera ser claro que j es un proyecto rentable para un cierto nivel de conocimiento que depende de j, que por lo tanto es endógeno y debiera ser considerado en la estimación. De (3) se infiere que j se realiza si es el proyecto más rentable que tiene la empresa.

Similarmente, se pude tener empresas que, dado su conjunto de proyectos disponibles, decidan no innovar. Este es el caso de empresas en las que:

$$\pi_j (X, C_j) < I (C_j) \text{ para todo j.}$$

Este es el tipo de empresas que al no innovar, generalmente declaran que no enfrentan barreras relevantes para la innovación.

3. Datos

Los datos a utilizar corresponden a los de la Octava Encuesta de Innovación en Empresas que desarrolla el Ministerio de Economía en conjunto con el Instituto Nacional de Estadísticas de Chile. Esta encuesta cuenta con información sobre el tipo de innovación (proceso, producto, organizacional o de marketing), sus efectos, la percepción que tiene la empresa de ciertas barreras u obstáculos, entre otros, para los años 2011 y 2012. Además, el diseño del formulario y la metodología de aplicación de esta encuesta siguen los lineamientos generales planteados por la OCDE en el Manual de Oslo (2005), y que la siguen EUROSTAT con la *Community Innovation Survey* (CIS) para el desarrollo de sus encuestas de innovación.

Si bien lo ideal sería poder contar con un panel de datos que permita conocer la evolución del proceso de innovación en las firmas, esto no es posible puesto que a pesar de que existen ocho rondas de la Encuesta de Innovación en Empresas en Chile, no se puede acceder a un registro que permita identificar a las empresas a lo largo de las diferentes encuestas. Por ello, se utilizan datos de corte transversal.

Estos datos fueron complementados con datos sobre el sistema educativo chileno del año 2012, donde se utilizó información sobre la matrícula total en dicho año para ciertas carreras de interés. Esta información es de carácter regional y se utilizó para construir variables que permitan caracterizar la oferta disponible de trabajadores calificados. Como quedará luego más claro, estas variables son necesarias como instrumentos que permiten intentar solucionar el problema de endogeneidad de los obstáculos de conocimiento.

En relación a los obstáculos a la innovación, la Encuesta de Innovación indaga por la relevancia percibida de distintos factores que obstaculizan o desincentivan la innovación. La empresa indica el grado que percibe de cada factor de acuerdo a la siguiente escala: (i) no es un obstáculo, (ii) baj9, (iii), medio y (iv) alto. Los factores se agrupan en 4 categorías: obstáculos financieros, obstáculos de conocimiento, obstáculos de mercado y otros obstáculos. En este caso, nos centramos en los obstáculos de conocimiento.

Los obstáculos de conocimiento y su percepción corresponden a cuatro factores[2]:

- Falta de personal calificado
- Falta de información sobre la tecnología
- Falta de información sobre los mercados
- Dificultad en encontrar cooperación para la innovación

La falta de capital calificado es un obstáculo a la innovación puesto que para desarrollar innovaciones se necesitan de un alto grado de conocimientos y habilidades en el personal. En este sentido, si la firma no tiene el personal adecuado, tanto en términos de conocimientos como de habilidades, se dificulta el proceso de innovación o incluso puede que finalice y desista su proyecto.

La falta de información sobre la tecnología se relaciona con los obstáculos de conocimiento ya que son problemas para identificar las tecnologías disponibles para innovar. Esto se puede deber a la falta de personal capaz de adquirir esta información, o bien a que dicha información no está disponible o es muy costosa de adquirir. En cualquiera de ambos casos corresponde a problemas de conocimiento por parte de la firma.

De la misma forma la falta de información sobre el mercado se asocia a los obstáculos de conocimiento. Este factor mide la información y conocimientos que posee la firma sobre el mercado, sea tanto de conocimientos sobre la competencia como información o predicciones sobre posibles innovaciones que desee llevar a cabo.

La dificultad en encontrar otros agentes (empresas, centros de investigación, universidades, etc.) para cooperar e innovar se asocia a los obstáculos de conocimiento, ya que mide las fuentes externas de la cuales se pueden absorber y aprender nuevas tecnologías y productos. De esta forma, si la firma percibe que es difícil encontrar socios para desarrollar innovaciones, puede ser que dicha dificultad radique en que la empresa necesita más conocimientos o capacidades de las que posee para llevar a cabo la innovación, lo que denota una escasez de conocimiento.

Se define la variable "obstáculos de conocimiento" como una variable binaria que toma el valor 1 si alguno de los factores antes mencionados es percibido como severo, mientras que toma valor 0 en caso contrario. En la Tabla 1 se presenta estadística descriptiva respecto a esta variable, donde vemos que un 52% de las firmas menciona percibir algún factor asociado al conocimiento como severo para restringir la innovación[3]. En comparación con otros obstáculos, su incidencia es similar a los de mercado, relativamente menor que los obstáculos financieros (62%) y superior a aquellos asociados a aspectos regulatorios (38%).

Las variables de innovación también se definen como una variable binaria, que toma el valor 1 si la firma declara haber introducido algún tipo de innovación durante los dos últimos años, sea esta de producto, proceso, organizacional o de marketing.

La estadística descriptiva en la Tabla 1 indica que un 23% de las firmas realizó algún tipo de innovación. Además, se aprecia que un 18% de las firmas realizó innovaciones tecnológicas (de producto o proceso), mientras que un 16% realizó innovaciones no tecnológicas (organizacional o de marketing).

Tabla 1. Innovación y Obstáculos

	Toda la muestra	Potencialmente Innovadoras
Innovación	0.23	0.26
Inn. Tecnológica	0.18	0.21
Inn. No Tecnológica	0.16	0.18
Obstáculos Conocimiento	0.52	0.59
Obstáculos Financieros	0.62	0.71
Obstáculos de Mercado	0.52	0.59
Obstáculos de Regulación	0.38	0.43

4. Estrategia Empírica

Como esta estrategia utiliza una medida directa (percepción de los obstáculos) del conocimiento sobre la innovación, se tomaron en cuenta los problemas que se generan en dichas estimaciones al tomar todas las firmas de la muestra. En este sentido, siguiendo lo planteado por Savignac (2008), para evitar el sesgo asociado a firmas que no innovan y no declaran percibir obstáculos, la muestra es restringida

(2) Si bien la variable consiste en preguntarle a los gerentes de las empresas su percepción sobre cada uno de estos factores, los resultados son similares si en lugar de la variable aquí descrita se utiliza la variable estandarizada.
(3) Estimaciones de cada factor por separado lleva a conclusiones similares respecto a su efecto negativo en innovación. Como están altamente correlacionados, incluirlos conjuntamente reduce la significancia de alguno de ellos y se hace difícil identificar su impacto por separado.

a firmas potencialmente innovadoras. Estas se definen como el grupo de firmas que han realizado alguna innovación o declaran que han enfrentado algún obstáculo para innovar. De esta forma, las firmas que no tienen interés en innovar son eliminadas de las estimaciones para evitar el sesgo de selección identificado en esta literatura (Savignac, 2008; Blanchard, et al., 2013; Mancusi & Vezzulli, 2010).

Para la estimación, se modela una variable latente *I* para la firma *i* en el sector *j* y localizada en la región *r*, como función de los determinantes tradicionales de la innovación y en la existencia de los obstáculos de conocimiento . Esto es:

$$I^*_{ijr} = \beta X_{ijr} + \delta C_{ijr} + S_j + S_r + \varepsilon_{ijr}$$

En los datos se observa si efectivamente la firma innovó o no, por lo que se define la variable binaria:

$$I_{ijr} = \begin{cases} = 1 & si\ la\ firma\ innovó \\ = 0 & si\ la\ firma\ no\ innovó \end{cases}$$

De esta forma, el modelo estimado corresponde a un Probit, donde la *propensión a innovar* es explicada por determinantes de la innovación (X) y por la existencia de Obstáculos de Conocimiento (C).

$$I_{ijr} = F(\beta X_{ijr} + \delta C_{ijr} + S_j + S_r + \varepsilon_{ijr} > 0)$$

I_{ijr} es una variable dummy que indica si la firma *i* en la industria *j* en la región *r* innovó. S_j son efectos fijos por industria y S_r son efectos fijos por región.

A pesar que la literatura previa encuentra que restringir la muestra a las firmas potencialmente innovadoras contribuye a solucionar el sesgo en la estimación del parámetro δ, pasando de positivo a negativo, de todas formas puede haber razones para que sigan existiendo problemas de endogeneidad. En primer lugar, la decisión de innovar y la severidad de la barrera de conocimiento pueden estar ambas afectadas por elementos heterogéneos no observables comunes, tales como la incertidumbre respecto a la dificultad del proyecto y a las capacidades de los empleados de resolver los problemas que aparezcan. En segundo lugar, la decisión de innovar y la severidad de los obstáculos de conocimiento pueden ser determinadas simultáneamente, ya que a medida que se innova es que los obstáculos dificultan el proceso.

Por lo tanto, además de restringir la muestra, se utiliza un modelo Probit Bivariado simultáneo[4], donde la existencia de obstáculos de conocimiento afecta la probabilidad de innovar y el comportamiento innovador induce la severidad del obstáculo de conocimiento.

$$\begin{aligned} I^*_{ijr} &= \beta_1 X_{ijr} + \delta_1 C^*_{ijk} + S_j + S_r + \varepsilon_{ijr} \\ C^*_{ijr} &= \beta_2 X_{ijr} + \delta_2 I^*_{ijr} + S_j + S_r + u_{ijr} \end{aligned} \qquad (6)$$

Para estimar este modelo se necesita una restricción de exclusión. En este caso, se asume que los obstáculos de conocimiento afectan a la innovación, pero que luego de controlar por los determinantes conocimiento, la innovación no afecta la percepción de este obstáculo. Es decir, al incluir variables que afectan C pero no I, se puede suponer que $\delta_2 = 0$.

Además de los obstáculos, basado en estudios previos similares, se incluyen como determinantes de la innovación las siguientes características de las empresas:

- Edad: Se considera esta variable para analizar si las firmas más antiguas innoven más o menos que las firmas más nuevas.
- Exportación: Si la firma exporta o no, porque el acceso a los mercados internacionales puede significar un aumento en la probabilidad de innovar ya que aumenta el grado de competencia (Harris & Moffat, 2011).
- Unidad I+D: Si la firma tiene una unidad formal o informal de Investigación y Desarrollo o bien gasta en I+D. Esto porque denota que la firma tiene las capacidades para innovar, independiente de si lo hace efectivamente o no. No todas las firmas que poseen departamento de I+D innovan, de hecho un 21% de las empresas que poseen o invierten en I+D no innovaron durante el periodo.
- Empleados Calificados: Calidad del capital humano de la empresa medido como la proporción de mano de obra calificada. Se incluye esta variable ya que una mano de obra más preparada implica que la firma posee mayor capacidad de aprender y quizás de innovar en nuevos procesos o productos.
- Cantidad de Empleados: Tamaño de la empresa medido como el logaritmo de la cantidad de empleados. Dicha variable se incluye en el modelo porque tal como ha enfatizado Schumpeter (1942), las firmas más grandes pueden tender a innovar más que las firmas pequeñas ya que pueden aprovechar sus economías de escala y otras características particulares.

En la Tabla 2 se encuentra la estadística descriptiva respecto a estas variables. Las primeras dos columnas de la tabla muestra estadística respecto a todas las firmas. En este caso, la edad promedio de las firmas es 14.9 años, el 5% de las firmas exporta, un 1,5% de las firmas posee un departamento de I+D, la proporción promedio de empleados calificados es 25% y el promedio del logaritmo trabajadores es 2.04. En las dos últimas columnas de la Tabla 2 se muestra la estadística para las firmas potencialmente innovadoras. Se aprecia que las medias de las variables son muy similares entre ambos grupos. En cambio, la Tabla 1 revela que los obstáculos son más relevantes para este tipo de empresas que para la muestra total.

Otras variables utilizadas en la estimación son aquellas utilizadas como restricción de exclusión y permiten la identificación causal del

(4) Una alternativa es usar un Probit con Variables Instrumentales (IV Probit), pero requiere que la variable endógena sea continua. En tal caso, utilizamos el promedio de la percepción de cada factor que compone los obstáculos de conocimiento. Los resultados son generalmente similares respecto a su efecto negativo en innovación, aunque su significancia es menor.

modelo. Estas variables deben estar correlacionadas con la percepción del obstáculo de conocimiento por parte de la firma, pero no deben correlacionarse con la innovación a través de otros canales. Para esto, se utilizan 2 variables de relacionadas al grado de conocimiento al que puede acceder o tiene acceso la firma.

Tabla 2. Estadística Descriptiva

	Toda la muestra		InnPot Inicial	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
Edad	14.90	12.02	15.03	12.44
Exportación	0.06	0.23	0.06	0.24
Unidad I+D	0.02	0.12	0.02	0.13
Emp. Calificados	0.26	0.32	0.25	0.32
Num. Empleados	2.05	1.44	2.09	1.43
Conocimiento SR	0.38	0.12	0.39	0.12
Cooperación SR	0.14	0.11	0.13	0.11
Conoc. Público	0.39	0.49	0.39	0.49
Prof	5.61	4.48	5.57	4.49

La primera variable intenta capturar el efecto de aumentos en la oferta regional de profesionales vinculados a la generación de conocimiento científico y tecnológico (Prof). Para esto, se considera la matrícula universitaria de pregrado[5] del año 2012 en las carreras de Ciencias y de Tecnología[6] de cada región y se multiplica por la proporción de empleados que tienen estudios universitarios o de postgrado en cada firma. Esta variable se basa en la interacción entre la oferta de mano de obra calificada de la región , y la demanda potencial de mano de obra calificada de la firma (δ_{ijr}). Se asume que la oferta de profesionales es exógena, ya que una firma no puede incidir en la oferta de mano de obra calificada de una región, y que las firmas se ven afectadas de distinta forma en función de su necesidad de mano de obra calificada.

En la ecuación de obstáculos se incluye una variable relativa al grado de información que posee la firma. Se define como una variable binaria igual a 1 si la firma conoce instrumentos de fomento público (Conoc. Público). Se asume que esta variable se correlaciona con el conocimiento, ya que mide información relevante que posee la firma para innovar, pero que no es un determinante de la innovación. De hecho, la pregunta es si conoce este tipo de instrumentos, no si ha aplicado a ellos o los ha utilizado. Para corroborar este supuesto, se probó esta variable como determinante de la innovación, encontrándose que no es una variable significativa.

Para controlar por el potencial impacto de otros factores asociados a la falta de conocimiento, se incluyen dos variables adicionales en esta ecuación. La primera es una variable que mide la propensión a cooperar en la industria y región (Cooperación SR). A mayor propensión a cooperar, se espera que las firmas enfrenten menores obstáculos de conocimiento. Se construye como el porcentaje de firmas que cooperaron en cada industria/región. La segunda, captura los factores comunes que constituyen obstáculos al conocimiento de las firmas. Se calcula como la proporción de firmas en la misma industria/región que declaran como severos a los obstáculos de conocimiento (Conocimiento SR).

5. Resultados

La Tabla 3 presenta los resultados de las estimaciones principales. Las columnas 1 y 2 corresponden a estimaciones con el total de firmas de la base, mientras que las columnas 3 y 4 solo consideran a las firmas potencialmente innovadoras. Las columnas 1, 2 y 3 corresponden a los efectos marginales de un modelo Probit y la columna 4 a un modelo Probit Bivariado.

En la columna (1) no se incluye la variable de obstáculo, pero se incluye en la columna (2). Al comparar ambos resultados, correspondiente a la totalidad de las firmas, se puede apreciar que la inclusión de los Obstáculos de Conocimiento no afecta significativamente los otros determinantes de la innovación. En ambas estimaciones, tanto si la firma exporta como si posee Unidad de I+D y el número de empleados afectan positiva y significativamente la propensión a innovar.

Es importante destacar que al incluir los obstáculos de conocimiento en la estimación con todas las firmas, el coeficiente de esta variable es positivo, aunque no significativo. Esto es consistente con lo discutido anteriormente relativo al sesgo de selección en este tipo de estimaciones al incluir a todas las firmas.

En las columnas 3 y 4 se corrige por este sesgo. La diferencia entre ambas columnas es que la columna 3 corresponde a los efectos marginales de una estimación Probit, mientras que la columna 4 son los coeficientes de un modelo Probit Bivariado. Si comparamos la columna 2 con la 3, vemos que al restringir la muestra el coeficiente de los Obstáculos de Conocimiento cambia al signo esperado: en este caso pasa a ser negativo. Al mismo tiempo, los determinantes de la innovación no sufren cambios mayores y los coeficientes se mantienen en torno a valores similares.

La columna 4 muestra un efecto negativo y estadísticamente significativo de los obstáculos de conocimiento, lo que indica que si se corrige tanto por el sesgo de selección como por endogeneidad, se encuentra que las firmas que presentan más obstáculos de conocimiento tienden a innovar menos. En esta columna, en términos de significancia y signo se mantienen los resultados referidos a los otros determinantes de la innovación. El efecto marginal es relativamente importante, indicando que una alta incidencia de obstáculos al conocimiento reduce la probabilidad de innovar en cerca de un 26%.

(5) Una mejor medida sería el número de egresados, pero no está disponible. En todo caso ambas debieran estar altamente correlacionadas entre regiones, salvo haya diferencias regionales muy marcadas entre matrícula y egreso.
(6) Las carreras de Ciencia son programas como Bachillerato en Ciencias y similares; Biología; Bioquímica; Física, astronomía y similares; Geología; Ingeniería estadística, estadística y similares; Licenciatura en Ciencias y similares, Licenciatura en matemáticas; Química y carreras similares; y Técnico en química, análisis químico y similares. En tanto que las de tecnología son Bioingeniería; Cartografía; Construcción Civil; Ingenierías e Ingenierías Civiles.

La estimación del Probit bivariado permite también analizar variables que afectan la severidad de los obstáculos de conocimiento. Los resultados indican que la información sobre instrumentos públicos y la disponibilidad de profesionales en ciencia y tecnología reducen la severidad de este obstáculo. El resto de las variables, en particular la propensión a cooperar y la severidad de los obstáculos en firmas similares no afectan la probabilidad que los obstáculos de conocimiento sean relevantes para las firmas.

Tabla 3. Determinantes de la Innovación Marginal Effects

	Toda la muestra		Potencialmente innovadoras	
	(1)	(2)	(3)	(5)
Innovación	Dprobit	Dprobit	Dprobit	Biprobit
Obs. Conocimiento		0.0348	-0.0139	-0.268***
		(0.0334)	(0.0381)	(0.0245)
Edad	-0.00129	-0.00131	-0.00146	-0.000729
	(0.00146)	(0.00145)	(0.00159)	(0.00133)
Exportación	0.205**	0.204**	0.219**	0.107
	(0.0880)	(0.0873)	(0.0939)	(0.0708)
Unidad I+D	0.577***	0.584***	0.595***	0.156
	(0.0946)	(0.0939)	(0.0867)	(0.108)
Emp. Calificados	0.0109	0.0158	0.00786	-0.00427
	(0.0527)	(0.0521)	(0.0610)	(0.0525)
Num. Empleados	0.0711***	0.0715***	0.0758***	0.0320**
	(0.00990)	(0.00996)	(0.0118)	(0.0128)
Obs. Conocimiento				
Conocimiento SR				-0.0660
				(0.0441)
Cooperación SR				-0.0385
				(0.0509)
Conoc. Público				-0.0172*
				(0.00904)
Prof				-0.00538**
				(0.00209)
Observations	4,590	4,590	4,050	4,050
Industria FE	Si	Si	Si	Si
Region FE	Si	Si	Si	Si

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Efectos por Tipo de Innovación

En esta sección, se presentan y discuten los resultados según el tipo de innovación que realiza la firma. Las innovaciones se pueden agrupar en dos grandes grupos: Innovaciones Tecnológicas e Innovaciones No Tecnológicas. Las Innovaciones Tecnológicas se refieren a innovaciones de proceso o producto que haya realizado la firma, mientras que las No Tecnológicas indican si la firma introdujo innovaciones organizacionales o de marketing.

El motivo de estudiar diferencias en cómo afecta el conocimiento a cada tipo de innovación es que estas innovaciones pueden ser de naturaleza distinta. Tal como sugiere Toner (2011), cada tipo de innovación requiere de insumos distintos, lo que repercute finalmente en los conocimientos necesarios y por ende probablemente en los efectos negativos de este obstáculo sobre la innovación de las empresas. De esta forma, es de esperar que el conocimiento afecte a todos los tipos de innovación, pero su relevancia podría ser distinta. Es difícil, sin embargo, indicar a priori si los obstáculos de conocimiento son más importante en innovaciones tecnológicas que no tecnológicas.

Además, con el objetivo de analizar si estas barreras han afectado mayormente la probabilidad de introducir innovaciones más novedosas, hacemos uso de la información de si las innovaciones de producto y procesos son consideradas como nuevas para el mercado y no sólo para la empresa. Esto es lo que calificamos como innovación tecnológica novedosa.

Tabla 4. Determinantes por Tipo de Innovación

Innovación	Tecnológica	No Tecnológica	Tecnológica Novedosa
Obs. Conocimiento	-0.269***	-0.253***	-0.119
	(0.0384)	(0.0345)	(0.200)
Edad	-0.000483	-0.00178	0.000409
	(0.00131)	(0.00109)	(0.000625)
Exportación	0.0280	0.107*	0.0625
	(0.0731)	(0.0618)	(0.0409)
Unidad I+D	0.163	0.0635	0.112**
	(0.191)	(0.0632)	(0.0479)
Emp. Calificados	-0.00903	-0.0143	0.00798
	(0.0535)	(0.0441)	(0.0307)
Num. Empleados	0.0253	0.0339***	0.00615
	(0.0206)	(0.0101)	(0.00562)
Obstáculos			
Conocimiento SR	-0.0474	-0.0588*	-0.0139
	(0.0390)	(0.0342)	(0.00892)
Cooperación SR	-0.0147	-0.0158	-0.00209
	(0.0480)	(0.0345)	(0.00853)
Conoc. Público	-0.0152*	-0.0135*	-0.00339
	(0.00838)	(0.00768)	(0.00364)
Prof	-0.00390**	-0.00341**	-0.000613
	(0.00180)	(0.00162)	(0.000584)
Observations	4,050	4,050	4,050
Industria FE	Si	Si	Si
Region FE	Si	Si	Si

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

En la Tabla 4 se presentan los resultados considerando los tres tipos de innovación: tecnológica, no tecnología y tecnológica novedosa. Los resultados respecto a los obstáculos para la probabilidad de innovar son similares para ambos tipos de innovaciones. Se encuentra que el efecto de los obstáculos de conocimiento es negativo y estadísticamente significativo para la probabilidad de introducir innovaciones tecnológicas y no tecnológicas. Más aún, para ambas, el impacto es una reducción en torno al 27%.

Respecto a la novedad de la innovación, aunque también se encuentra un efecto negativo en torno al 11%, éste es no significativo. Esto indica que el bajo grado de novedad de las innovaciones de las empresas chilenas responde a otro tipo de problemas y no necesariamente a los obstáculos de conocimiento que ellas mismas declaran. Esto puede ser una pregunta relevante para futuras investigaciones respecto a qué factores limitan la introducción de innovaciones más novedosas.

5. Conclusiones

En esta investigación, se ha analizado cómo los obstáculos de conocimiento afectan la innovación de las firmas chilenas. Consistente con la evidencia internacional que utiliza obstáculos auto-reportados en las encuestas de innovación, nuestro trabajo confirma que es necesario utilizar una muestra adecuada y corregir por la endogeneidad de los obstáculos para estimar correctamente su efecto causal de estos obstáculos. En particular, se restringe la muestra a las firmas potencialmente innovadoras y se utiliza un Probit bivariado con restricciones de exclusión, las que corresponden a variables asociadas con la disponibilidad de personal calificado y el conocimiento de programas públicos.

Los resultados indican que los obstáculos al conocimiento afectan negativamente la probabilidad de innovar. Este efecto se encuentra tanto para las innovaciones tecnológicas como no tecnológicas. En términos cuantitativos su efecto es relevante. En ausencia de estos obstáculos, la probabilidad de innovar se incrementaría en un 26%. Este efecto es comparable al impacto de las restricciones financieras encontrado por Alvarez y Crespi (2015), las que de eliminarse, incrementarían la probabilidad de innovar en un 32%.

También se estudia el efecto sobre la novedad de la innovación, y se encuentra que el impacto de los obstáculos de conocimiento no e significativo. Esto indica que el bajo grado de novedad de las innovaciones de las empresas chilenas puede responder a otro tipo de problemas. Futuras investigaciones podrían indagar en más detalle respecto a qué factores limitan la introducción de innovaciones más novedosas y cómo su impacto podría diferir de acuerdo a otras características de las empresas como tamaño y localización.

Nuestros resultados tienen implicancias de política importantes considerando que muchos de los programas públicos en innovación son basados en la existencia de restricciones financieras. Esta evidencia, junto a otra reciente a nivel mundial, indica que es necesario profundizar en la implementación de programas que afecten más directamente a otros obstáculos a la innovación.

En relación a los determinantes de estos obstáculos, se encuentra que mayores niveles generales de información y la oferta de capital humano especializado contribuyen a que estas barreras sean percibidas como menos severas. En este sentido, se requiere analizar cómo las firmas reciben y adquieren información, y de qué manera las políticas públicas podrían contribuir a mejorar en esa dimensión. También, en lo relativo al capital humano, nuestros resultados indican que programas de inserción de profesionales en la empresa podrían ayudar en este sentido.

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Apoyo público e innovación a nivel de firmas

Andrés Jung [1*], *Diego Karsaclian* [1]

Resumen: Este artículo pretende aportar a la literatura que analiza los efectos de las políticas públicas sobre la innovación a nivel de firmas, a partir del caso de una pequeña economía en desarrollo, Uruguay. Analiza la relación entre apoyo público y probabilidad de innovar para el mercado, e introduce un rezago entre el apoyo otorgado y la innovación realizada, de manera de valorar rezago en el impacto. El análisis econométrico utiliza Probit binomiales con corrección de Heckman, para corregir sesgos de selección. Se concluye que los apoyos públicos importan a los efectos de innovar para el mercado, ya sea porque estimulan la innovación o porque la facilitan en empresas que ya innovan. Asimismo, las actividades de innovación de empresas asociadas a apoyos públicos, en Uruguay, no parecen requerir de largo tiempo de maduración. Finalmente, se sugiere profundizar el estudio de la relación entre internacionalización de las empresas y probabilidad de innovar.

Palabras claves: innovación; subsidios; evaluación de política.

Abstract: Title: *Public support and innovation at the firm level.* This article intends to contribute to the analyses of the effects of public policies on innovation at the firm level, based on the case of a small developing economy (Uruguay). It studies the relation between public support and the probability of innovating at the market level, introducing a lag between support and innovation. The econometric analysis uses binomial Probit models with Heckman sampling bias correction. The article concludes that public support matters for innovation at the market level, whether by stimulating innovation or by facilitating it in already innovative firms. Moreover, the innovation activities of Uruguayan firms receiving public support do not seem to require a long time to develop. Finally, it is suggested that the relation between firm internationalization and the probability of innovating be further studied.

Keywords: innovation; subsidies; policy evaluation.

Submitted: March 10th 2017 / Approved: September 25th 2017

Introducción

El desarrollo económico se asocia actualmente a procesos de diversificación productiva que, a través de la generación de capacidades por parte de los agentes económicos, conducen a economías más complejas y con mayor potencial de crecimiento (Hausmann & Klinger, 2006; Hausmann & Rodrik, 2003; Imbs & Warcziarg, 2003).

Para diversificar la matriz productiva y transformar las economías, se requiere que las empresas innoven. En países en desarrollo, las innovaciones que tienen estos efectos no deben ser necesariamente algo nuevo para el mundo. Aunque su alcance sea el mercado (Hausmann & Rodrik, 2003), pueden tener un impacto significativo, asociado con el desempeño a nivel de firma y con los aumentos en la productividad total de los factores a nivel nacional (Navarro *et al.*, 2016; Maloney y Perry, 2005). Este hecho es particularmente relevante para los países de América Latina, donde las deficiencias en la capacidades nacionales de innovación han sido una de las principales barreras para el crecimiento (Maloney, 2002).

Esto explica que, de manera creciente, los países presten atención a los procesos de innovación en las empresas y desarrollen políticas para promoverlos, y que a nivel académico se analice la relación entre políticas de innovación y desempeño innovador. Esta relación ha sido ampliamente estudiada para países desarrollados, aunque no lo ha sido tanto para países emergentes.

Las políticas de apoyo a la innovación abarcan un amplio espectro de objetivos y acciones. Si bien la innovación se materializa cuando se transforman nuevas ideas en soluciones sociales y económicas (Navarro *et al.*., 2016), principalmente por parte de empresas públicas o privadas (Edquist, 2011), o el conocimiento en valor económico (Camacho *et al.*, 2010), la propia inversión en actividades de innovación (ej. en I+D) ya es un componente crítico para el crecimiento a largo plazo (Navarro *et al.*., 2016). Estas actividades no solo generan nuevo conocimiento asociado a una innovación, sino que son importantes para desarrollar capacidad de absorción, es decir para adquirir y adaptar tecnologías existentes a nuevas situaciones (Cohen & Levinthal, 1989; García-Granero *et al.*, 2014).

El hecho de que las políticas se orienten tanto a facilitar el acceso al mercado de una nueva idea ya concebida, como a promover conocimiento que permita generar nuevos productos o procesos, que luego serán llevados al mercado, pone de manifiesto la relevancia de considerar los tiempos requeridos para que una medida de apoyo a la innovación logre tener el impacto deseado. Este es un aspecto escasamente analizado en la literatura. Puede esperarse que apoyos orientados a generar conocimiento (ej. I+D), requieran de mayor tiempo para manifestar sus efectos que apoyos más cercanos a la introducción de un nuevo producto o proceso en el mercado.

Este tema es relevante para países en desarrollo. Como plantean Szczygielski *et al.* (2017), las políticas públicas de apoyo a la inno-

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vación en las empresas en países 'seguidores en tecnología' pueden ayudar o no a las economías a avanzar en la 'escala tecnológica'. Pero no todas las políticas son pertinentes para ello y, en particular, es importante considerar el rezago entre apoyo público e innovación a nivel de firma.

El objetivo de este artículo es aportar a la creciente literatura que analiza los efectos de las políticas públicas sobre la innovación a nivel de firmas, a partir del caso de una pequeña economía en desarrollo, como es Uruguay. Los aportes principales son dos: a) analiza la relación entre el otorgamiento de apoyos públicos y la probabilidad de las firmas de innovar a nivel de mercado, ya que es a este nivel que las innovaciones aportan a la transformación de las economías; y b) introduce en el análisis un rezago entre el apoyo otorgado y la innovación realizada por las empresas, de manera de valorar los tiempos de impacto y, en consecuencia, reflexionar sobre el tipo de apoyo otorgado. Ambos aspectos son importantes, ya que si las innovaciones a nivel de mercado son las que transforman las economías (Cowling, 2016), es posible focalizar mejor las políticas y, en función de la 'cercanía al mercado' de los instrumentos utilizados, puede valorarse la rapidez de su impacto esperado en términos de innovación.

El artículo se estructura de manera que, luego de esta introducción, se discuten los aspectos más relevantes de la literatura (sección 2), y en la sección 3 se presentan los datos y la metodología de análisis. En la cuarta sección se discuten los principales resultados del análisis empírico, para finalmente concluir en la sección 5.

Las políticas públicas y la innovación

Los argumentos conceptuales en que se basan las políticas de innovación provienen básicamente de dos corrientes teóricas: la neoclásica y la evolucionista.

Desde la primera, la principal justificación de la intervención pública se basa en la idea de que los niveles de inversión en innovación por parte de las empresas tienden a ser menores a lo socialmente óptimo, debido a la existencia de fallas de mercado. En general, éstas se asocian al uso de poder de mercado, la existencia de externalidades y las asimetrías de información.

La principal falla de mercado que identifica la literatura es la existencia de externalidades positivas. La innovación involucra la generación de conocimiento cuya completa protección no es posible o es costosa y, a pesar de que la imitación tiene sus costos (Hall & Lerner, 2009), termina comportándose como un bien público. Como consecuencia, las empresas innovadoras no pueden incorporar todos los beneficios de sus inversiones en innovación, lo que determina una brecha entre el óptimo social y el privado (Aboal & Garda, 2015).

El enfoque evolucionista, por su parte, está vinculado a los sistemas nacionales de innovación. En este caso, la intervención pública se justifica para mitigar eventuales fallas que tienen que ver con la conectividad y las capacidades individuales y organizacionales para el funcionamiento de un sistema de innovación (Edler *et al.*, 2013). Estos sistemas están constituidos por un conjunto de agentes económicos, instituciones y prácticas que participan de manera relevante en los procesos de innovación. Desde un enfoque complementario, también pueden definirse a partir de actividades o determinantes de la innovación (Edquist, 2011). Los actores de estos sistemas a nivel nacional son, entre otros, empresas, universidades, agencias públicas, sistemas financieros y mercados, que contribuyen a generar, diseminar, usar, adaptar e incorporar conocimiento en los sistemas de producción y en la sociedad (Freeman, 1987; Metcalfe, 1995), conformando el marco en el que se desarrollan las políticas de apoyo a la innovación por parte de los gobiernos (Navarro *et al.*, 2016).

Las políticas públicas se justifican de manera creciente en una orientación proactiva para acelerar y viabilizar ciertos desarrollos que se consideran socialmente deseables (Edler *et al.*, 2013). Muchas veces no se explicitan las lógicas sobre las que se basa la formulación de las políticas y los análisis se centran en los impactos que estas pueden alcanzar y no en los problemas que podrían resolver (Edquist, 2011). La evaluación de los impactos, sin embargo, es compleja. Hay varias razones por las que las políticas de apoyo a la innovación podrían no tener los efectos buscados (Andrews & Criscuolo, 2013). Además del conocido "crowding out" del apoyo público sobre la inversión privada en innovación, pueden generarse incentivos para la captura de rentas por parte de las empresas, lo que puede llevar a una mala asignación de los recursos disponibles por parte de las agencias responsables de las políticas.

Por otra parte, las políticas de innovación deben articularse con otras, orientadas a promover la competitividad empresarial y a mejorar el complejo entorno en el que las empresas desarrollan su actividad (ej. Durán *et al.*, 2016; Padilla-Pérez & Gaudin, 2013; Edquist, 2011; Magro & Wilson, 2013; Dogson *et al.*, 2011). Las condiciones de contexto y las capacidades de las empresas, condicionan el efecto de los instrumentos directos de apoyo a la innovación (Edler *et al.*, 2013), por lo cual resulta importante prever acciones de mejora en diversos niveles para un mayor impacto (Cowling, 2016; Andrews & Criscuolo, 2013). La interacción entre las políticas también puede generar efectos no previstos, ya que nuevos instrumentos son introducidos en contextos donde ya existen otras políticas (Cunningham *et al.*, 2013, Flanagan *et al.*, 2011, OCDE, 2010). Finalmente, el horizonte temporal necesario para evaluar los resultados de la política de innovación son extensos y, al menos en América Latina, los instrumentos son modificados antes de que se pueda concluir una evaluación real de su impacto (Durán *et al.*, 2016).

Existe una amplia literatura que analiza empíricamente la relación entre políticas de apoyo a la innovación y el comportamiento innovador de las empresas. La mayor parte se refiere a países desarrollados y, en particular, al sector manufacturero. Esta literatura se ha centrado en su mayoría en los efectos de las políticas sobre la magnitud del gasto en I+D realizado por las empresas (ej. Afcha, 2012) y en la evaluación de la existencia o no de "crowding-out" de los fondos públicos sobre la inversión privada. En cuanto al efecto sobre la inversión en I+D, en general se verifica una relación positiva con el apoyo público a nivel de firmas. En relación al "crowding-out", David *et al.* (2000) repasaron 35 años de evidencia econométrica acumulada al respecto y encontra-

ron efectos de sustitución solo en un tercio de los estudios.
En cuanto a la literatura que analiza el efecto de las políticas sobre el desempeño innovador de las empresas, los resultados no son del todo concluyentes. Así, Aerts y Czarnitzki (2004) analizaron los efectos de las políticas de innovación sobre las solicitudes de patentes para empresas flamencas, sin encontrar resultados significativos. Czarnitzki *et al.* (2011), en cambio, sí encontraron un impacto positivo de las políticas en el número de innovaciones en producto introducidas por empresas canadienses del sector manufacturero, con efectos incluso en innovaciones para el mercado (tanto local como internacional), al igual que Czarnitzki y Hussinger (2004) para el caso de un grupo de empresas alemanas. Cowling (2016) estudió los efectos de créditos impositivos orientados a promover la innovación en el caso de PYMES británicas. Encontró evidencia de que la herramienta fomentó las innovaciones en procesos de las empresas, y que este efecto se potenciaba cuando la empresa contaba con altos niveles de planificación estratégica y de capacidad.

Edler *et al.* (2013) realizaron un compendio de la evidencia disponible, revisando más de 800 informes de evaluación de efectividad de políticas de innovación implementadas en países desarrollados. Encontraron que el conjunto de la evidencia sugiere que las medidas fiscales tienen un efecto positivo en las innovaciones incrementales (en oposición a las radicales) y en las innovaciones en procesos, aunque no se ha comprobado que estas tengan efectos en la productividad de las empresas. En particular, la evidencia acerca de los efectos de las medidas de subsidio directo en los resultados innovadores de las empresas es contradictoria.

En el caso de los países emergentes, donde los problemas de información son mayores, los resultados tampoco son concluyentes. Szczygielski *et al.* (2017), analizan los casos de Polonia y Turquía como países 'seguidores en tecnología' respecto a países avanzados, encontrando que el apoyo a I+D se asocia positivamente con la innovación a nivel de firma, aunque no así el subsidio para la generación de capacidades. Para América Latina, Hall y Maffioli (2008) compendiaron los resultados de evaluaciones que realizó el BID sobre los efectos de políticas de fondos de desarrollo tecnológico para Argentina, Brasil, Chile y Panamá entre 2005 y 2007. Por un lado, la evidencia que analizaron sugiere que los fondos no generan efecto sustitución y que estos afectan positivamente la intensidad del gasto en I+D, además de favorecer una actitud más proactiva respecto a las actividades de innovación. De cualquier manera, no encontraron resultados estadísticamente significativos de impacto en el número de patentes, ventas de productos innovadores, o crecimiento en la productividad de las empresas, probablemente debido al escaso horizonte de tiempo en el que las evaluaciones fueron realizadas. Aboal y Garda (2015) analizaron el caso de Uruguay, concluyendo que el apoyo público incrementó el gasto privado en innovación, el gasto privado en I+D y el número de ventas innovadoras en las empresas. Sin embargo, sus resultados muestran que el otorgamiento de apoyos no habría tenido efectos considerables sobre el gasto privado en innovación por parte de empresas que invertirían en este tipo de actividades incluso si no recibiesen apoyo público.

Si bien la evidencia empírica no es concluyente para países en desarrollo, en términos de los efectos de las políticas públicas sobre el comportamiento innovador de las empresas, existen indicios de una asociación positiva (ej. Cowling, 2016; Czarnitski *et al.*, 2011; Edler *et al.*, 2013). En particular, ello parece ser el caso para países de América Latina (Hall & Maffioli, 2008), lo que hace relevante el tema ya que es una región que tiene deficiencias en sus sistemas nacionales de innovación (Maloney, 2002). Dado que, como señala Cowling (2016), las innovaciones 'para el mercado' son las que promueven la transformación de las economías hacia estructuras más diversificadas, complejas y con mayor potencial de crecimiento, lo que es importante para el desarrollo de los países (Hausmann *et al.*, 2007; Hausmann & Rodrik, 2003), resulta de interés evaluar la posible asociación positiva entre el apoyo público y la probabilidad de introducir productos o procesos que sean nuevos para el mercado (sea local o internacional).

A partir de lo anterior, se fomula la siguiente hipótesis:

Hipótesis 1: Existe una asociación positiva entre el otorgamiento de apoyo público a las empresas para desarrollar actividades de innovación y la probabilidad de que estas innoven a nivel de mercado (local e internacional).

En todo caso, el análisis de la relación entre los apoyos públicos y el comportamiento innovador de las empresas debe incorporar información referida a varios períodos. Una de las dificultades para evaluar el efecto de las políticas hace referencia al tiempo requerido para que los instrumentos tengan efectos sobre los resultados de la actividad innovadora de la empresa (Edler *et al.* 2013). Este es un aspecto relevante ya que apoyos más orientados a la generación de conocimiento (ej. I+D) pueden requerir un tiempo mayor de maduración. El uso de instrumentos orientados a apoyar la transformación de conocimiento en valor de mercado, puede mostrar resultados más rápidamente. Incluso, se han identificado casos en los cuales un efecto positivo de ciertos tipos de apoyo público en el comportamiento innovador de las empresas en el corto plazo, se diluye en el tiempo (ej. Bakhshi *et al.*. 2013). Szczygielski *et al.* (2017), incorporan este aspecto en su análisis evaluando la asociación entre apoyos realizados en un período y actividades innovadoras en un período siguiente. Ello parece interesante en el caso de países de América Latina, en los que la inversión en conocimiento (ej. I+D) es relativamente baja, y existen numerosos instrumentos orientados a apoyar la transformación de conocimiento en valor (Durán *et al.*, 2016), lo que permitiría esperar una mayor cercanía en el tiempo entre apoyo recibido e innovación realizada.

En función de lo anterior, para el caso de estudio, se formula la siguiente hipótesis:

Hipótesis 2: La probabilidad de que una empresa innove a nivel de mercado (local e internacional) es mayor cuando recibe apoyo público en períodos cercanos a la introducción de la innovación en el mercado.

Datos y metodología

Datos

Para el análisis se fusionaron las bases de las rondas 2007–2009 y 2010–2012 de la Encuesta de Actividades de Innovación a empresas uruguayas que lleva a cabo la ANII (Agencia Nacional de Investigación e Innovación).

La muestra quedó conformada por 1459 empresas, 716 pertenecientes al sector manufacturero y 743 al sector de servicios, con personal ocupado promedio mayor o igual a 5 personas y con ventas mayores o iguales a 120 millones de pesos. La encuesta cubre la totalidad de los subsectores manufactureros y parte de los subsectores de servicios[1]. Al fusionar las bases, se dejaron de lado aquellas empresas con menos de 4 años de actividad a 2012, y se eliminaron algunos casos que podían distorsionar el análisis (básicamente empresas públicas y microempresas).

A los efectos del estudio, se consideraron innovaciones en producto y en proceso, incorporando en esta última categoría innovaciones en organización y comercialización. Como puede esperarse dada su complementariedad (Cowling, 2016), en ambos sectores se detecta una fuerte correlación entre innovación en producto y en procesos: 76% de las empresas industriales y 74% de las de servicios que innovaron en procesos también innovaron en producto. Asimismo, dada su importancia en términos de transformación de la estructura productiva, se consideraron las innovaciones 'para el mercado', sea éste local o internacional (ej. Cowling, 2016; Szczygielski *et al.*, 2017), distinguiéndolas de las innovaciones 'para la empresa'.

En la tabla 1 se presentan el número de empresas innovadoras para ambos sectores, así como la cantidad de empresas por tipo de innovación (como porcentaje del total de empresas de cada sector) y la cantidad de empresas por alcance de sus innovaciones (como porcentaje del total de empresas innovadoras en el sector respectivo).

Tabla 1. Características de la muestra

	Industria	Servicios
Número de observaciones	716	743
Empresas innovadoras	278	238
Porcentaje del total	38,8%	32,0%
Tipo de innovación (como porcentaje de las empresas innovadoras)		
Producto	52,9%	48,7%
Proceso*	87,1%	87,4%
Alcance máximo de la innovación (como porcentaje de las empresas innovadoras)		
Empresa	59,0%	68,5%
Mercado**	41.0%	31,5%

Fuente: Elaboración propia en base a ANII
* Incluye innovaciones en organización y comercialización
** Incluye innovaciones a nivel internacional

En la tabla 2 se presentan las medias de distintas variables para las empresas no innovadoras, innovadoras en general e innovadoras para el mercado de cada sector. Se observa que las empresas innovadoras tienen una mayor cantidad de años en actividad, mayor cantidad de personal total y de personal calificado, mayor intensidad exportadora y mayor porcentaje de empresas con capital extranjero. La productividad laboral de las empresas innovadoras es mayor en la industria pero no en los servicios. En general estos rasgos se profundizan a nivel de empresas que innovan para el mercado, excepto para el caso de la productividad de la mano de obra.

Las empresas innovadoras que utilizan las herramientas de apoyo público son una minoría y son un grupo relativamente menor en el sector servicios (13.5% de las empresas innovadoras) que en el industrial (34.5% de las empresas innovadoras). El proceso de selección permite acceder a los apoyos a la mayor parte de las empresas que lo solicitan: el 86.5% de las empresas industriales y un 74.4% de las de servicios que solicitan apoyo lo obtienen.

La fuente de apoyo a la que recurren mayoritariamente la empresas (sean industriales o de servicios) para desarrollar actividades de innovación es la Ley de inversiones (72% de las empresas industriales y 59% de las de servicios), si bien no es un instrumento diseñado específicamente para la promoción de la innovación. Esta Ley prevé un crédito fiscal por inversiones, que se aprueba caso a caso, y que mejora en general las condiciones de competitividad de las empresas. Estas inversiones pueden incluir incorporación de nuevos equipamiento y tecnologías y otras inversiones asociadas al proceso de innovación. La segunda fuente en importancia es el apoyo canalizado a través de la ANII, que consiste en subsidios directos a actividades de innovación que también son aprobadas caso a caso (18% de las empresas industriales y 27% de las de servicios recibieron apoyo de esta fuente). Existen otras fuentes de menor peso relativo. En todo caso, la muestra permite determinar si las empresas que accedieron a estos apoyos públicos lo recibieron en el período 2007-2009 (un 29%), en el periodo 2010-2012 (54%), o en ambos (17%).

(1) Incluye empresas pertenecientes a las secciones: D. Suministro de electricidad, gas, vapor y aire acondicionado, E. Suministro de agua; alcantarillado, gestión de desechos y actividades de saneamiento (excluyendo las Divisiones 37 y 39), H. Transporte y almacenamiento, I. Alojamiento y servicio de comida, J. Información y comunicación, M. Actividades profesionales, científicas y técnicas, N. Actividades administrativas y servicios de apoyo, y Q. Servicios sociales y relacionados con la Salud Humana (excluyendo las Divisiones 87 y 88). Los subsectores considerados en la encuesta representaban en 2010 63% del VAB y 58% del personal ocupado en el sector

Tabla 2. Estadísticas descriptivas

Sector	Industria			Servicios		
Resultados innovadores	No innova	Innova	Innova para el mercado	No innova	Innova	Innova para el mercado
Apoyo público (2010 – 2012, porcentaje que recibió apoyo).	0,5%	34,5%	39,5%	1,0%	13,5%	22,7%
Edad (años)	29,0	33,7	33,7	22,1	25,5	25,5
Tamaño (cantidad de empleados)	65,8	154,9	180,7	124,5	278,3	267,8
Intensidad exportadora	14,7%	21,0%	23,0%	5,8%	7,1%	7,9%
Capital extranjero (porcentaje que tiene capital extranjero).	10,3%	19,4%	18,4%	10,9%	17,2%	26,7%
Empleo calificado	8,0%	13,2%	15,5%	18,6%	29,4%	36,0%
Productividad laboral (ventas sobre cantidad de empleados, en miles de pesos)	2784	3372	2897	1839	1761	1562

Fuente: Elaboración propia en base a ANII

Metodología

El propósito del análisis es estimar en qué medida la probabilidad de que una empresa innove a nivel de mercado está asociada al hecho de que haya recibido o no apoyo público para financiar actividades de innovación y al momento en que lo recibió. Para el análisis econométrico se utilizaron modelos Probit binomiales con método de corrección de Heckman (Heckprobit) para mitigar potenciales problemas de sesgos de selección en las muestras (ej. Cowling, 2016; David *et al.*, 2000; Szczygielski *et al.*, 2017).

El problema de sesgo de selección surge del hecho de que solo es posible observar el nivel de alcance de las innovaciones de las empresas que efectivamente tuvieron alguna innovación. El método de Heckman, que se desarrolla en dos etapas, consiste en estimar un primer modelo "de selección" que estima la probabilidad que tiene una empresa de innovar (cualquiera sea el nivel de alcance) para luego incorporar las estimaciones transformadas de este primer modelo como variables explicativas adicionales al modelo "principal", que estima las probabilidades de que la innovación haya logrado ser novedosa a nivel de mercado. Específicamente, para controlar la posibilidad de selectividad implícita al excluir a aquellas empresas que no son innovadoras, las estimaciones del modelo principal son corregidas por un "regresor de selección", estimado utilizando el modelo de selección. La variable dependiente de este último modelo toma el valor 1 si la empresa tuvo algún tipo de innovación y 0 si no lo tuvo.

El modelo de selección fue especificado con un mayor número de variables explicativas que el modelo principal. Las variables incorporadas fueron dummies subsectoriales y de localización geográfica (Montevideo – resto del país). Siguiendo a Cowling (2016), estas variables fueron introducidas pues podrían captar efectos de derrame dentro de sistemas de innovación sectoriales o regionales que aumentan la probabilidad de innovar.

Formalmente, los modelos Probit simples estiman la probabilidad de que la empresa innove a nivel de mercado $Pr(Y_i = 1|X_i)$ como una función de sus variables independientes. La estimación se realiza a través del método de máxima verosimilitud. De esta forma se tiene que:

$$Pr(Y = 1|X_i) = \Phi(X_i\beta + \varepsilon)$$

Donde Xi es un vector de variables independientes, β sus coeficientes y la Φ función de distribución acumulativa de la distribución normal estándar, que transforma cualquier valor real en un número (probabilidad) entre 0 y 1.

El modelo Probit con sesgo de selección supone que existe una relación subyacente entre la variable dependiente y las independientes, representada a través de la ecuación latente:

$$Y_j^* = X_j\beta + \varepsilon_1$$

Tal que solo es observable el resultado binario:

$$Y_j^{probit} = (y_j^* > 0)$$

A fin de captar los efectos de las variables no observadas (en este caso las que no innovan), se estima mediante un Probit simple una ecuación de selección que asume el valor 1 si se cumple:

$$Z_j\gamma + \varepsilon_2 > 0$$

Donde el vector de variables independientes Zj equivale al Xi más las variables adicionales subsectoriales y de localización geográfica. Las estimaciones de este modelo son incorporadas al modelo principal. Por último, se tiene que:

$$corr\,(\varepsilon_1, \varepsilon_2) = \rho$$

Donde ρ es la correlación entre los errores de las dos ecuaciones estimadas (la del modelo de selección y la del modelo principal). Cuando ρ≠0, existe una correlación entre los términos de error de ambas ecuaciones, por lo que un modelo Probit simple produciría resultados sesgados. El método Heckprobit corrige este sesgo y provee estimadores consistentes y eficientes para los parámetros del modelo.

De esta manera, se estima para cada sector (industria y servicios) y cada tipo de innovación (producto o proceso) un modelo cuya variable dependiente es la probabilidad de que la empresa introduzca una innovación a nivel de mercado. En todos los casos, el modelo de selección tiene por variable dependiente si la empresa tuvo una innovación del tipo correspondiente al del modelo principal (esto es, producto – producto, proceso – proceso) cualquiera haya sido su alcance. En todos los casos, las variables dummies de innovación corresponden al segundo período de los datos de la encuesta (2010-2012). En el caso de las innovaciones en producto para el sector servicios, se estimó un modelo Probit simple, dado que no se encontró evidencia de sesgo de selección.

Se realizaron diversas pruebas adicionales a los efectos de comprobar la robustez de los resultados. Se estimaron los modelos considerando únicamente a las empresas que no recibieron apoyo público para la innovación en el segundo período y se realizaron las pruebas de heterescedasticidad de Breusch-Pagan / Cook-Weisberg, rechazándose la hipótesis nula de varianza constante en todos los casos. En función de estos resultados, todos los modelos fueron estimados con errores estándares robustos.

Variables independientes

La tabla 3 contiene detalles sobre la operacionalización de las variables explicativas a introducir en los modelos, la que sigue criterios habitualmente utilizados en la literatura (ej. Cowling, 2016; Czarntiski & Lopes-Bento, 2011).

Tabla 3. Operacionalización de variables

Variable	Definición
Apoyo	La empresa recibió apoyo del Estado para financiar actividades innovadoras. En el modelo la variable identifica cuatro situaciones distintas: si recibió apoyo en el primer período, si recibió apoyo en el segundo, si recibió apoyo en ambos, o si no recibió apoyo. Las fuentes de apoyo estatal son: ANII, CARPE, Ley de Inversiones (COMAP), Fondo Industrial (DNI) y Otras instituciones.
Edad	Cantidad de años transcurridos desde que la empresa inició actividades hasta el último año de la encuesta (2012).
Tamaño	Cantidad de personal empleado, promedio anual del período 2010 - 2012.
Intensidad exportadora	Porcentaje del ingreso por venta proveniente de ventas al exterior, promedio anual del período 2010 - 2012. Se introduce en el modelo como cuatro dummies: No exportadora (0%), 0%>25%, 25%>80% y 80%>100%.
Capital extranjero	Variable dummy, adopta el valor 1 si al menos parte del capital de la empresa es de origen extranjero y 0 si no tiene capital extranjero.
Empleo calificado	Porcentaje del personal que cuenta con algún tipo de calificación (cantidad de técnicos y profesionales con los que contaba la empresa en el año 2012 sobre el total de empleados en 2012).
Productividad laboral	Promedio de ventas anuales en el período 2010 – 2012 sobre promedio de personal ocupado en ese mismo período (en pesos corrientes)

Las variables de edad, tamaño, empleo calificado y productividad laboral fueron introducidas en el modelo con una transformación logarítmica debido a la fuerte distribución asimétrica hacia la derecha que presentan sus datos.

En la tabla 4 se presentan las matrices de correlación entre las variables explicativas del modelo para ambos sectores. Ninguna de las correlaciones representa un problema para la estimación.

Tabla 4. Matrices de correlaciones

Industria	Apoyo	Edad	Tamaño	Intensidad Exp.	Capital Ext.	Empleo calificado
Edad	0.1426*					
Tamaño	0.2347*	0.2369*				
Intensidad exp.	0.0777*	0.0206	0.3824*			
Capital ext.	0.0385	0.0290	0.3807*	0.3901*		
Empleo calificado	-0.0290	-0.0177	-0.4701*	-0.0424	0.0625	
Prod. laboral	0.1471*	0.2008*	0.3373*	0.3542*	0.3352*	0.0644
Servicios	**Apoyo**	**Edad**	**Tamaño**	**Intensidad Exp.**	**Capital Ext.**	**Empleo calificado**
Edad	0.0553					
Tamaño	0.1792*	0.2314*				
Intensidad exp.	0.0507	-0.0651	-0.0431			
Capital ext.	0.0222	-0.0668	0.1423*	0.2073*		
Empleo calificado	0.0434	-0.0223	-0.2181*	0.0282	0.0328	
Prod. laboral	0.0726*	0.1790*	-0.0726	0.2338*	0.2520*	0.1861*

Resultados

El análisis de los resultados (Tabla 5) muestra, para todos los casos analizados, que efectivamente existe una asociación positiva y significativa entre el apoyo público y la probabilidad de introducir innovaciones a nivel de mercado por parte de las empresas. Los coeficientes positivos indican que las empresas que han recibido apoyo público tienen mayor probabilidad de innovar para el mercado (sea local o internacional), en comparación con una empresa que no lo ha recibido. Si bien no es posible comprobar el sentido de la causalidad, ello permite confirmar la Hipótesis 1, independientemente del sector (industria o servicios) y del tipo de innovación (producto o proceso).

Tabla 5. Modelos estimados

Variables	Sector Industrial		Sector Servicios	
	Innovación de mercado en producto	Innovación de mercado en proceso	Innovación de mercado en producto	Innovación de mercado en proceso
	Coeficiente E.E. Robusto	Coeficiente E.E. Robusto	Coeficiente E.E. Robusto	Coeficiente E.E. Robusto
Apoyo				
1er período	-0.580 .326	0.242 .283	0.403 .357	-0.159 .771
2do período	0.649*** .200	0.738*** .191	0.775*** .286	0.966*** .272
Ambos	0.671** .303	1.370*** .279	1.427* .476	1.029* .592
Edad	0.012 .097	0.079 .110	-0.117 .124	-0.066 .628
Tamaño	0.086 .079	0.151** .072	0.069 .062	0.141** .065
Int. export.				
0% > 25%	0.423** .183	0.033 .191	0.752*** .207	0.451*** .248
25% > 80%	-0.113 .231	0.237 .226	--- 	-0.345 .378
80% > 100%	0.005 .264	0.497* .272	0.142 .396	-6.859*** .589
Capital ext.	0.054 .201	-0.477** .245	0.478** .200	0.216 .246
Empleo calif.	0.058*** .019	0.023* .014	0.054*** .017	0.026* .016
Prod. laboral	0.023 .303	0.162** .073	0.042* .065	0.159* .084
Diagnósticos:	Heckprobit N = 716 Censuradas = 569 No cens. = 147 Wald X2(11) =54.83 Prob > X2 = 0.0000 L.L.= -391.5584	Heckprobit N = 716 Censuradas = 474 No cens. = 242 Wald X2 (11) = 78.68 Prob > X2 = 0.0000 L.L.= -480.1411	Probit N = 698 LR X2(10) = 78.70 Prob > X2 = 0.0000 Pseudo R2 = 0.2070 L.L. = -150.70506 AIC: 0.472	Heckprobit N = 738 Censuradas = 530 No cens. = 208 Wald X2 (11)=1927.58 Prob > X2 = 0.0000 L.L.= -471.2635

Código: * p < 0.10, ** p < 0.05, *** p < 0.01

En segundo término, se observa que la asociación es positiva y significativa siempre que se haya recibido un apoyo en el mismo período (de 3 años) en el que la empresa innovó (2010-2012), incluso en el caso en que este apoyo se venga dando desde un período anterior (2007-2009). No se encontraron asociaciones significativas entre los apoyos otorgados solamente en el período anterior al que corresponde a la innovación y la probabilidad de innovar para el mercado. Este resultado permite validar la Hipótesis 2. La cercanía temporal entre apoyo e innovación para el mercado sugiere que las empresas solicitan (o reciben) apoyo sólo una vez que han decidido o están procesando la introducción de la innovación.

En cuanto a las variables de control, en el caso de innovaciones en producto para ambos sectores y en procesos para los servicios, se observa una asociación positiva entre la probabilidad de innovar nivel de mercado y ser exportador con una intensidad exportadora de hasta 25% de las ventas. Para el sector industrial, en el caso de innovaciones en procesos, esta asociación se verifica para una alta intensidad exportadora, lo que podría explicarse por la estructura de exportaciones de Uruguay y la necesidad de sus empresas de ser más eficientes para competir en los mercados internacionales, más que de introducir nuevos productos en dichos mercados. Para los servicios, en el caso de innovación en procesos, se observa una asociación negativa y significativa con la intensidad exportadora de más de 80%. Los resultados estarían indicando que las empresas de servicios no exportadoras o con una relativamente baja intensidad exportadora tienen mayores probabilidades de innovar a nivel de mercado en procesos que las empresas de alta intensidad exportadora.

En cuanto al tamaño, el porcentaje de personal calificado y la productividad laboral, los resultados van en línea con lo esperado. La presencia de capital extranjero no muestra resultados significativos, salvo una asociación positiva en el caso de innovación en producto en los servicios.

Conclusiones

La preocupación de los países por generar procesos de desarrollo de sus economías a través de mayor productividad, diversificación y complejidad de su estructura productiva, ha puesto de relieve la importancia de las políticas de apoyo a la innovación a nivel de las empresas. En particular, el mayor énfasis está puesto en la introducción de productos y procesos nuevos 'para el mercado' (sea local o internacional), dado su impacto en la transformación de la estructura productiva (Cowling, 2016).

El tema adquiere mayor relevancia considerando el contexto de la innovación en América Latina y, en particular, en Uruguay. Respecto a los estándares de la OCDE, estos países exhiben niveles bajos de inversión y de resultados en innovación, así como de calidad educativa y de recursos humanos destinados a la investigación (Maloney & Perry, 2005). Este contexto debilita a los sistemas nacionales de innovación y pone de relieve la importancia de las políticas de apoyo. Lo que no está claro es la efectividad de las políticas aplicadas. Este artículo pretende realizar un pequeño aporte en este sentido, desde el caso de Uruguay. Los resultados obtenidos permiten extraer algunas conclusiones que, si bien con limitaciones, pueden aportar sugerencias para el futuro.

En primer lugar, y aunque sin poder identificar causalidades, se concluye que los apoyos públicos importan para la innovación a nivel de mercado, ya sea porque estimulan a las empresas a innovar o porque facilitan esta actividad en las empresas que ya lo hacen o tienen decidido hacerlo. Dado que la amplia mayoría de las empresas que recibieron apoyo lo hicieron a través de la Ley de Inversiones, instrumento que no tiene un foco específico en promover la actividad innovadora (Durán *et al.*, 2016; Aboal *et al.,* 2015), parece relevante repensar la estructura de apoyos públicos con un sesgo más "pro-innovación".

En segundo término, se observa que las actividades de innovación que desarrollan las empresas asociadas a los apoyos públicos, en el caso de Uruguay, no requieren largo tiempo de maduración. Probablemente más que actividades de generación de conocimiento se trate de actividades de incorporación y adaptación de productos y tecnologías vigentes en otros países. Esto destaca la importancia del fortalecimiento de la capacidad de absorción de las empresas lo que les permitirá sacar partido de vínculos y generación de conocimiento externo. Esto que ha sido comprobado para el caso del emprendimiento innovador en países en desarrollo (Gonzalez-Pernía *et al.*, 2015), parece también aplicable a este caso.

En tercer lugar, si bien no es el foco del análisis, se observa que en tres de los cuatro casos estudiados existe una relación positiva entre algún grado de internacionalización de las empresas a través de su intensidad exportadora y la probabilidad de innovar. Existe una extensa literatura sobre la relación entre innovación e internacionalización (ej. Cassiman *et al.*, 2010; Roper & Love, 2002; Wakelin, 1998), vínculo que se comprueba también en este caso, lo que sugiere que debería estudiarse la mejor manera de articular las políticas de apoyo a una y otra actividad.

De cualquier manera, el análisis debe ser tomado con cuidado ya que presenta algunas limitaciones. Si bien la muestra de empresas de servicios tiene una amplia cobertura, no abarca a todos los subsectores. No se consideran empresas con menos de 4 años de existencia ni a aquellas empresas que dejaron de funcionar entre uno y otro período. Esto último podría estar introduciendo un sesgo al solo considerar las empresas "supervivientes".

Como sugerencias para futuras investigaciones, resulta interesante la utilización de otras técnicas econométricas que permitan avanzar en el análisis de causalidad, como son el análisis de panel de datos o el emparejamiento por puntaje de propensión (Aboal & Garda, 2015). De la misma manera, es interesante profundizar en los resultados de la investigación sobre la interacción entre internacionalización e innovación, a los efectos de aportar a un mejor diseño y gestión de políticas.

Adicionalmente, es importante remarcar la importancia y necesidad de otro tipo de estudios para evaluar y comprender mejor el fenómeno

de la innovación y el efecto de las políticas de apoyo. Si bien los análisis econométricos arrojan resultados relevantes, el seguimiento a empresas receptoras de apoyo podría dar la oportunidad de comprender mejor los factores de éxito, lo que conformaría un insumo valioso para el diseño y la gestión de estas políticas.

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Innovación en gestión de recursos humanos: la relevancia de las redes inter-organizativas de intercambio de conocimiento

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Resumen: El presente artículo utiliza metodología de redes sociales para analizar empíricamente el posible impacto positivo de la participación en redes de intercambio de conocimiento para la implementación de innovaciones en gestión de GRH. Los resultados indican que aquellas empresas que participan activamente en el establecimiento de relaciones de intercambio de conocimiento de GRH con otras empresas, tanto a través de acuerdos formales-contractuales como mediante relaciones informales-colaborativas, tienen una propensión mayor a realizar innovaciones en esta área. Como resultado, las empresas más expuestas a nuevos conocimientos son en mayor medida más innovadoras en sus sistemas de gestión de GRH. Se concluye que el establecimiento de relaciones inter-organizativas tiene efectos positivos en la introducción de prácticas innovadoras de gestión de GRH.

Palabras clave: Innovación; redes sociales; gestión de recursos humanos; redes inter-organizacionales; intercambio de conocimiento; innovación en gestión de personas; relaciones colaborativas.

Abstract: Title: *Innovative human resource management: the salience of inter-firm knowledge networks*.
This work draws on social network analysis to empirically assess the relationship between firm participation in inter-firm knowledge networks and innovation in human resource management (HRM). Results suggest that participation in the establishment of inter-firm knowledge exchanges, both through formal and informal networks and relationships, has a positive relationship with the implementation of HRM innovations. Findings suggest that firms that actively participate in inter-firm knowledge networks obtain knowledge resources and tend to be more innovative in the HRM system and practices.

Keywords: Innovation; social networks; human resource management (HRM); inter-firm networks; knowledge networks; knowledge exchange; innovation in people management; collaborative relationships.

Submitted: May 2nd 2017 / Approved: September 8th 2017

Introducción

Para las empresas que tratan de ser competitivas en un entorno económico de creciente dinamismo y complejidad las posibilidades de supervivencia residen, con frecuencia, en la capacidad para movilizar, integrar y administrar múltiples recursos con el fin de afrontar la incertidumbre y las exigencias propias de las estrategias innovadoras (Martin-Rios y Pasamar, 2017). Uno de los recursos críticos que requiere ser gestionado eficazmente son las personas que conforman la organización (Huselid, 1995). En concreto, la literatura ha prestado especial atención al desarrollo de prácticas de gestión de recursos humanos (GRH en adelante) altamente innovadoras con las que atraer, motivar y retener satisfactoriamente a las personas claves de la organización (Martin-Rios, 2014; Martin-Rios y Erhardt, 2016; Martin-Rios, Pougnet y Nogareda, 2017). Dicha literatura ha constatado que una GRH eficaz constituye una fuente potencial de ventaja competitiva sostenida para las empresas (Lepak y Snell, 2002). Buena parte de estos estudios fundamentan sus hallazgos en los principios de la teoría de los recursos y las capacidades para hacer hincapié en la naturaleza única de cada organización y en la explotación de sus diferencias con otras empresas para obtener ventajas competitivas sostenibles (Barney, 1991; Dierickx y Cool, 1989; Martin-Rios y Erhardt, 2017; Wright, Dunford y Snell, 2001). De tal forma que la apropiación de conocimiento en GRH y su puesta en práctica para gestionar de forma efectiva el capital humano constituye un recurso estratégico que contribuye a innovar en GRH para diferenciarse y aventajar a la competencia (Martin-Rios, 2014; Paauwe y Boselie, 2005).

Curiosamente, a pesar de la extrema relevancia que tiene la obtención de conocimiento de GRH en la posterior implementación de innovaciones en GRH, la literatura se ha mostrado reticente a analizar en profundidad cuáles son los canales a través de los que se intercambia dicho conocimiento y qué efectos tiene la participación en dichos intercambios en las dinámicas innovadoras en GRH de las empresas (Martin-Rios, 2014). Las lagunas en la literatura académica presentan oportunidades de avanzar nuestro conocimiento. En concreto, el presente estudio hace frente a dos cuestiones centrales: *¿qué características y propiedades estructurales poseen las redes inter-organizacionales para el intercambio de conocimiento de GRH?* Asimismo, *¿cuál es la relación entre la participación en la red —en términos de posibilidades de intercambio de conocimiento de GRH—y la implementación de innovaciones en este campo?*

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ISSN: 0718-2724. (http://jotmi.org)

La atención del estudio se centra en la importancia de las características y propiedades estructurales de las relaciones formales y las relaciones de colaboración como factores que la literatura de redes inter-organizativas señala que tienen un mayor impacto en el intercambio de conocimiento (Martin-Rios y Septiem, 2013; Septiem y Martin-Rios, 2011). Este análisis es especialmente pertinente a la hora de analizar los aspectos estructurales del intercambio de conocimiento (tales como la intensidad y la frecuencia de las relaciones) que relacionan la participación en redes de conocimiento y la implementación de innovaciones (por ejemplo, la posición de centralidad en la red).

La organización del artículo es la siguiente: en primer lugar, se revisa la literatura relativa al intercambio de conocimiento entre empresas según los diversos modelos de relaciones existentes. A continuación, desde la teoría de las redes sociales se analizan las características y propiedades estructurales que influyen en el establecimiento de intercambios de conocimiento, específicamente los intercambios de conocimiento en GRH. A continuación se explicitan los modelos de investigación utilizados. En el apartado de resultados se analiza la existencia de relaciones y el grado de participación de las empresas que participan en redes de intercambio de conocimiento de GRH y los mecanismos estructurales e instrumentales que subyacen a estas redes. Concluimos con un conjunto de implicaciones para la práctica y la investigación.

Revisión de la literatura

Teoría organizacional de la red social y las relaciones inter-organizacionales

La teoría de las redes sociales ofrece razones teóricas por las cuales las empresas pueden participar activamente en el intercambio de conocimiento de GRH entre organizaciones. Dentro de la investigación organizacional de la red social (Granovetter, 1979; Kilduff y Brass, 2010; Rubinstein et al., 2016), los investigadores han examinado el papel de las redes para sugerir que el establecimiento y la participación en relaciones inter-organizacionales ofrecen beneficios a las empresas en forma de circulación de conocimiento (Martin-Rios y Erhardt, 2017; Martin-Rios y Septiem, 2013). Recientemente, dentro de la literatura de gestión empresarial, los investigadores han expresado su interés en las redes de intercambio de conocimiento como una prioridad para aquellas empresas cuyo objetivo es participar en los flujos de conocimiento (Parmigiani y Rivera-Santos, 2011). Estos estudios en general, destacan el papel de los factores económicos y sociales en el impulso de la participación de la empresa, partiendo de trabajos anteriores que hacían hincapié en los factores institucionales relativos a las presiones externas y las presiones de la conformidad normativa (Fligstein, 1985; Westphal y Zajac, 1997) [1].

En lo que respecta al análisis de las redes de intercambio de conocimiento, la investigación se ha centrado en dirimir la relevancia de las relaciones tanto formales como informales entre organizaciones, que favorecen el intercambio y la prestación conjunta de conocimiento sobre diversos aspectos relativos al ámbito tecnológico, productivo (productos y/o servicios) y de gestión organizativo (Powell y Grodal, 2005; Sammarra y Biggiero, 2008). Específicamente, estos estudios examinan el impacto que dichas relaciones tienen en diversos resultados empresariales, tales como el aprendizaje organizacional y la innovación (Alexander y Childe, 2013). En general, se considera que las redes inter-empresariales y el intercambio del conocimiento que se produce en ellas es una práctica arraigada (Uzzi 1996), que favorece unos niveles considerables de intercambio (Powell, Koput, y Smith-Doerr, 1996), en base a relaciones descentralizadas (focos de poder repartidos) (Sammarra y Biggiero, 2008) y niveles significativos de reciprocidad (Easterby-Smith et al., 2008). Dichas redes adquieren, con frecuencia, carácter formal (contractual o estratégico), son altamente selectivas y centralizadas. Es decir, un número limitado de empresas ocupan las posiciones centrales (por ejemplo, grandes multinacionales como el grupo Toyota) y definen las posibilidades de acceso al resto de empresas (en el ejemplo, distribuidores, suministradores y clientes de Toyota) (Dyer y Nobeoka, 2000). Más recientemente, la literatura ha revelado la existencia de redes informales o colaborativas entre empresas (Cross, Nohria y Parker, 2012). Estas relaciones carecen a priori de carácter comercial y, por ende, tanto el acceso como la posición que ocupan los diversos actores es menos selectivo que en las redes formales.

Un argumento recurrente sugiere que la proximidad física y cognitiva entre empresas e instituciones favorece un mejor acceso a los flujos de conocimiento y representa una mejora en la capacidad innovadora de estas empresas (Uzzi, 1996). Sin embargo, Breschi y Lissoni (2001) sugieren la necesidad de nuevas investigaciones orientadas a mejorar nuestra comprensión del intercambio de conocimientos localizados, cuestionando que la información y el conocimiento fluyan sin restricciones en las redes locales. Particularmente importantes son las nuevas herramientas metodológicas en la medición de la difusión del conocimiento a través del Análisis de Redes Sociales (ARS) (Borgatti, 2007), que han permitido una mejor comprensión de los elementos generadores de redes de conocimiento.

Las relaciones inter-organizacionales de intercambio de conocimiento en GRH

Uno de los escenarios más apropiados para la difusión y adquisición de conocimiento es a través de la red social, definida como el patrón de comunicación, amistad, asesoramiento o apoyo que existe entre los miembros de un sistema social (Burt & Minor, 1983). Las redes sociales, sus características y estructura son cruciales para determinar los flujos de difusión de ideas, innovaciones o experiencias (Burt & Minor 1983; Scott 1991; Wellman 1983). Al utilizar el concepto de red social hacemos referencia a la teoría de redes y el análisis estructural o de redes sociales según la cual las personas se encuentran conectadas unas con otras formando canales de comunicación e influencia (Granovetter, 1985) a través de los que tienen lugar también las relaciones inter-organizacionales. Por ello la teoría de redes sociales se utiliza ampliamente como marco conceptual para el estudio del intercambio de ideas y conocimiento en una amplia variedad de contextos, incluido el inter-organizacional.

(1) Por ejemplo, Fligstein (1985) analizó la propagación de formas multidivisionales y Burns y Wholey (1993) exploraron la adopción de estructuras matriciales. Otros autores han analizado el intercambio de conocimientos en relación a los procesos del bloqueo de intercambio de una red (e.g. Westphal y Zajac, 1997) o la adopción de innovaciones en el campo de la medicina (e.g. Coleman, Katz y Menzel, 1966; Becker, 1970).

Sin embargo, buena parte de la literatura de GRH ha centrado su atención en analizar los flujos de conocimiento de GRH en el nivel intra-organizativo. Por ejemplo, bajo el enfoque de la dirección internacional de recursos humanos, diversos estudios han analizado la transferencia de conocimiento de prácticas específicas de GRH (tales como la evaluación del desempeño o el sistema de establecimiento de incentivos) desde la sede central de la multinacional a sus diversas subsidiarias (Björkman y Lervik, 2007; Martin-Rios y Erhardt, 2008), o entre organizaciones participantes en joint ventures internacionales y alianzas estratégicas (Schuler, Jackson, y Luo, 2003).

En base a la evidencia empírica señalada en el anterior apartado, cabría esperar un mayor número de estudios sobre la existencia e importancia de la trasmisión de conocimiento de GRH entre empresas independientes. Sin embargo, la literatura sobre dichos intercambios es limitada como diversos estudios ponen de manifiesto (Brass, 1995; Legnick-Hall y Legnick-Hall, 2003; Martin-Rios, 2014). La mayor parte del trabajo realizado hasta la fecha se ha enfocado en analizar la difusión de determinadas prácticas de RH. Por ejemplo, el trabajo de Williamson y Cable (2003) se centra en los procesos de selección de los equipos de alta dirección para sugerir que el contexto social en el que las empresas están imbricadas determina la toma de decisiones en temas de GRH, tales como las decisiones de contratación entre las empresas Fortune 500). Asimismo, Mazza y Alvarez (2000) analizan la función de los periódicos y la de prensa popular en la difusión de conocimiento de GRH. Dichos estudios ponen de manifiesto la relación positiva entre el establecimiento de relaciones contractuales entre empresas y el intercambio conocimiento de GRH (Martin-Rios y Erhardt, 2008; Schuler, Jackson, y Luo, 2003). Cabe esperar que dichos intercambios tengan lugar asimismo cuando las relaciones se establecen de manera informal y cooperativa. Sin embargo, la falta de estudios no permite respaldar estas afirmaciones. Asimismo, hay una carencia de estudios sobre el efecto que el intercambio de conocimiento en GRH entre empresas independientes tiene en el esfuerzo innovador en GRH por parte de las empresas involucradas.

El presente estudio contribuye a solventar parte de estas carencias mediante un análisis empírico de las relaciones de intercambio de conocimiento de GRH entre empresas independientes ubicadas en un parque científico y tecnológico. Para analizar todas estas cuestiones nos basamos en un enfoque multidisciplinar que integra las ideas de la investigación sobre los flujos de conocimiento entre organizaciones (Easterby-Smith, Lyles, y Tsang, 2008; Powell, Koput y Smith-Doerr, 1996) y la teoría de redes sociales (Granovetter, 1985), que nos aportará una visión desde la perspectiva de la red social para analizar empíricamente los factores mencionados en los procesos de intercambio.

Contexto y Metodología

Los parques científicos y tecnológicos

Los grupos de empresas de ciencia y tecnología conocidos como "parques" surgieron en los EE.UU. en la década de 1950, en un intento por aumentar la productividad de empresas de base tecnológica por la proximidad física o la aglomeración territorial (Castells y Hall, 1994) de dichas empresas con las administraciones públicas, los centros de I+D y las universidades. Tras su éxito en los EE.UU., dichos clusters se extendieron a Europa en los años 60 y 70 (por ejemplo, Cambridge en Reino Unido, Sophia-Antipolis en Francia, o Medicon Valley en Dinamarca-Suecia) y al sur de Asia en los 80 y 90 (por ejemplo, A*START en Singapur).

La lógica detrás de estos parques tecnológicos fue que la proximidad de la industria tecnológica puede ayudar en la formación de vínculos de red y facilitar contactos entre empresas y, en particular, favorecer las interacciones interpersonales a través de las cuales el conocimiento se espera que sea intercambiado (Diez-Vial y Montoro-Sanchez, 2016; Sammarra y Biggiero, 2008).

El parque de ciencia y tecnología que hemos seleccionado para nuestra investigación se encuentra en el área metropolitana de Madrid (España). En el año 2000, una universidad pública junto con organismos públicos locales, regionales y nacionales, puso en marcha el parque. Hoy día constituye un ejemplo de parque científico y tecnológico donde la universidad ha sabido combinar una incubadora de empresas y el apoyo institucional a la alta tecnología de reciente creación (start-ups), junto con los servicios básicos a las empresas ya consolidadas en el mercado (algunas de ellas, con varios años de antigüedad). La universidad a través de su oficina de apoyo a empresas oportunidades para el desarrollo de flujos de conocimiento y el fomento de la innovación. Como tal, desempeña un papel preponderante en la creación y desarrollo de las relaciones entre empresas.

El parque se compone de 38 empresas (la mayoría de ellos miembros de la asociación local de empresarios[2]), incluyendo las start-ups, las empresas establecidas, y las subsidiarias de empresas multinacionales. La incubadora de empresas incluye proyectos empresariales e ideas (cinco en total) y 12 spin-offs universitarios y de desarrollo de proyectos empresariales. Por último, hay seis centros de I+D financiados con fondos públicos, incluidos dos institutos de investigación y consorcios de I+D entre empresas y la universidad.

Recogida de datos

El análisis de las redes sociales estudia, tanto las redes completas, es decir, todos los vínculos que contienen las relaciones específicas dentro de una población definida, como las redes personales (también conocidas como redes egocéntricas), donde los lazos estudiados son los que desarrollan las personas individuales (comunidades personales). Para obtener una mejor comprensión del intercambio de conocimientos de GRH entre empresas se optó en este estudio por una red completa de empresas (todas las empresas pertenecientes al PCT). Si bien cada empresa puede y, a menudo mantiene, relaciones de intercambio con actores fuera del parque (otras empresas, organismos e instituciones), por cuestiones de proximidad y con el fin de analizar una única red de dimensiones manejables, el presente análisis se centra en los intercambios que cada empresa ubicada en el parque mantiene con el resto de empresas también ubicadas en el parque.

(2) La asociación de empresas del PCT, nace por iniciativa de las propias empresas, en principio para solucionar problemas surgidos en la llegada al parque. Como algún entrevistado comentó: "al principio tratábamos temas como de 'comunidad de vecinos', pero también nos sirvió para conocernos y establecer relaciones comerciales...".

Hemos elaborado un cuestionario para trazar el intercambio de conocimiento entre empresas, a través de las personas con responsabilidades para el mantenimiento de relaciones con otras empresas (por ejemplo, directores generales y directores de GHR). El cuestionario sociométrico se basa en las líneas directrices aceptadas en la literatura especializada (en particular, Borgatti, Everett y Freeman 2002; Scott, 2001). La encuesta incluye un listado completo de todas las empresas del PCT, que comprende un total de 51, con exclusión en la muestra de todos los proyectos de negocios en la incubadora de empresas y todos los centros de I+D sin una visión clara del negocio. Este método de lista se ha demostrado fiable en otras investigaciones pues facilita al entrevistado recordar los patrones típicos de interacción (Diez-Vial y Montoro-Sanchez, 2016; Kumar, Stern y Anderson, 1993).

El trabajo de campo duró ocho semanas. Incluyendo la Oficina de Tecnología del PCT Leganés, nuestra muestra estuvo conformada por 51 empresas. Se localizó telefónicamente a cada gerente, de forma que cada empresa tuvo una probabilidad de participar en el estudio del 100%. Finalmente, se administró el cuestionario a 41 empresas, lo que representa una tasa de respuesta del 80,4%. Las otras 10 empresas declinaron la participación tras varias llamadas telefónicas o, en algunos casos, no pudieron ser contactados. Las entrevistas personales se realizaron con un director ejecutivo o alto directivo por empresa. El método de informante único se ha considerado adecuado tanto en la investigación de GRH como en la de redes sociales (Borgatti y Cross, 2003; Huselid, 1995).

La Tabla 1 presenta los datos descriptivos de la muestra. La edad promedio de las empresas es de 17 años, siendo de 85 años la más antigua de las empresas. El noventa por ciento de las empresas son pequeñas y medianas empresas (PYMEs), mientras que el 10 por ciento son grandes empresas con más de 200 empleados y unas ventas superiores a 15 millones de euros. De acuerdo a la clasificación CNAE-2009, veintisiete de las empresas entrevistadas (53%) trabajan en servicios de alta tecnología y trece (25,5%) son empresas manufactureras de alta o media-alta tecnología.

Tabla 1. Descriptivos

Variable	Distribución de frecuencias (N=51*)				
Antigüedad (años)	Menos de 10	11-30	31-50	Más de 51	Total
Valor (%)	17(33.3%)	25(49.0%)	6(11.8%)	3(5.9%)	51(100%)
Sector industrial +	MAT	MMAT	SAT	Otros	Total
Valor (%)	6(11.8%)	7(13.7%)	27(52.9%)	11(21.6%)	51(100%)
Empleados	Menos de 25	25-50	51-200	Más de 201	Total
Valor (%)	15(35.7%)	10(23.8%)	13(31%)	4(9.5%)	42(100%)+
Facturación (Mill. €)	Menos de 1	1-15	Más de 15		Total
Valor (%)	10(23.8%)	22(52.4%)	10(23.8%)		42(100%)+
Origen negocio	Independiente	Spin-off	Subsidiaria multinacional		Total
Valor (%)	38(74.5%)	10(19.6%)	3(5.9%)		51(100%)

* Incluyendo la Oficina de Transferencia

\+ MAT: manufactura alta tecnología; MMAT: manufactura media-alta tecnología; SAT: servicios alta tecnología

\+ 9 casos perdidos

! 1 caso perdido

A los encuestados se les pidió hablar de esas organizaciones con los que había intercambiado información de GRH en los últimos seis meses. Los encuestados tuvieron que elegir sus respuestas de una lista que contiene todas las empresas (50) del Parque. No había ninguna restricción sobre el número máximo de selecciones que cada encuestado podía hacer. Clasificamos las relaciones dentro de la red real entre los actores i, j, k en formal (transaccional) e informal (personal) o de asesoramiento o relacionada con el grado de confianza (relacional) (Friedman y Podolny, 1992). A los encuestados se les dio ejemplos del tipo de conocimiento para clasificar el tipo de intercambio de información de gestión de GRH. Se les suministró un listado de prácticas de gestión de personas con 10 diferentes prácticas (entre ellas, reclutamiento, selección, formación, compensación y evaluación del desempeño), que los investigadores han utilizado con frecuencia en el campo estratégico de GRH (Huselid, 1995).

Junto al cuestionario de redes sociales, los entrevistados completaron un cuestionario con una serie de preguntas relativas a la GRH en la propia empresa. En una de ellas se solicitó que señalasen cuáles de las prácticas de GRH del listado habían sido introducidas o substancialmente mejoradas en los dos últimos años (con anterioridad a la realización de este estudio) Asimismo, se preguntó por los motivos por los que dichas prácticas de GRH fueron puestas en marcha. De esta forma se puede investigar la relación entre la participación en intercambio de conocimiento e innovación en prácticas de GRH.

Análisis de la red

Los datos de la red investigada fueron procesados utilizando el paquete de software UCINET (Borgatti et al., 2002). Los mapas de red o "sociogramas" que se presentan a continuación se desarrollaron mediante la NetDraw (Borgatti, 2007). Los sociogramas representan la red como

un conjunto de nodos que representan a las empresas y un conjunto de líneas dirigidas (las líneas que unen los nodos) (Moreno, 1934) que indican la presencia del intercambio de conocimientos entre los empresas. En la red analizada, los lazos tienen puntas de flecha que indican la dirección de la colaboración. La posición central de cada firma (es decir, el número de lazos que una empresa tiene con otras empresas) está representado por el tamaño del nodo (es decir, mayores nodos representan mayores centralidades) y el valor de los lazos (es decir, la fuerza de la relación) puede ser observado por su espesor (los valores más altos están representados por una línea más gruesa). Los paquetes de software, como los utilizados en esta investigación, de forma automática transforman los datos estadísticos de red para generar sociogramas.

Los datos de la red se introdujeron en una matriz para calcular los índices de la red, que describen la cohesión de toda la red, lo que indica la presencia de las relaciones de red entre las empresas participantes (Reagan y McEvily, 2003) y también la probabilidad de participación en los diversos flujos de conocimiento (Scott, 1991).

Estructura de la red

Las propiedades estructurales y relacionales definen los aspectos de la configuración de la red y proporcionan información sobre la estructura de las relaciones sociales de estas redes. El análisis estructural examina las relaciones entre las unidades de análisis en lugar de las propiedades individuales de las unidades (Coleman, 1958) para examinar cómo las redes de relaciones se originan. La centralización de la red es una medida a nivel de red que cuantifica el grado jerárquico de la red (Freeman, 1979). Para este trabajo se calcularon tres medidas: centralización, densidad y reciprocidad de las relaciones.

La centralización se calcula mediante la adición de la suma de las diferencias en la centralidad del actor más central a todos los demás y se normaliza dividiendo por el máximo posible de todos los grafos conectados (Borgatti y Everett, 1997). Cuando la medida es grande (valor máximo de 1), significa que los agentes centrales son muy pocos y que los agentes restantes ocupan posiciones mucho menos centrales en la red. Por el contrario, si la centralización de la red es baja (un valor mínimo de 0), significa que la red está poblada por actores que ocupan posiciones centrales de manera similar. También se calculó la media de la centralidad de grado, que se define como un valor medio global de la cantidad de vínculos que tiene un nodo, ya sea de salida (grado de salida) o de entrada (grado entrante) y mide el nivel de participación de una empresa en una red.

La densidad estructural analiza el número de enlaces entre los miembros de la red con respecto al número de enlaces posibles y se registra como un porcentaje (Scott, 1991). La densidad es una indicación de cómo unida es una red y la fuerza de esas relaciones (Wasserman y Faust, 1994). Los valores de densidad varían desde 0 a 1. El valor calculado para cada red de conocimiento permite interpretar la densidad de los flujos de conocimiento entre las empresas como un índice de la probabilidad de que las empresas intercambien sus conocimientos. También se calculó la suma total del conocimiento compartido o la suma de los grados, que describen la cantidad total de las relaciones a través de las cuales el conocimiento se espera que sea compartido.

La reciprocidad se define como la relación del número de lazos que son recíprocos con el número total de los lazos (Wasserman y Faust 1994), donde M es el número de parejas completas mutuas y A las díadas asimétricas en la red. Las puntuaciones de esta medida son las proporciones que van desde 0 a 1. La reciprocidad, por tanto, es referida para determinar la fuerza del vínculo (Granovetter, 1979) o la fuerza de la relación informal entre las empresas, que mide la frecuencia con que las empresas intercambian recíprocamente con respecto al número de intercambios e indica el flujo unidireccional de una empresa a otra. Los enlaces recíprocos se postulan para indicar que lazos son más fuertes que los enlaces unidireccionales. La reciprocidad es un indicador adecuado del grado de reciprocidad y el intercambio recíproco en una red, que se refiere a la confianza, la cohesión social y la credibilidad.

Intercambio de conocimiento e innovación

De acuerdo con la literatura inter-organizacional, el establecimiento de relaciones y la participación en intercambios entre empresas aumenta la capacidad innovadora y la probabilidad de que las empresas lleven a cabo iniciativas de innovación (Appleyard, 1996; Powell y Grodal, 2005; Sammarra y Biggiero, 2008). Puesto que, hasta la fecha, no se han llevado a cabo estudios que analicen la participación en redes y la actividad innovadora en el ámbito de GRH, en este estudio analizamos dicha relación mediante un análisis por el que segregamos las empresas en dos grandes categorías: por un lado, las empresas que participan en intercambios de GRH a través de redes formales, contractuales (intercambio formal) y en segundo lugar, las empresas que participan en redes de intercambio colaborativo o informales (intercambio informal). Entonces, operacionalizando el tipo de intercambio construimos una matriz de 50x50, donde la codificación de cada empresa como "1" si ambas organizaciones en la díada participan del mismo intercambio y "0" si no participan.

A continuación hemos operacionalizado la innovación en GRH. Al igual que en el caso del tipo de intercambio, se ha creado una matriz de 50x50, según si la tasa de introducción de innovaciones en GRH es baja (la empresa llevo a cabo innovaciones en menos de un 30% de las prácticas de GRH propuestas), media (hasta un 60%) o alta (innovaciones en 61% o más actividades de GRH) en los dos últimos años. Si bien en términos absolutos pueden considerarse unos niveles altos de innovación, son relativamente característicos de las empresas de alta tecnología. La codificación de cada empresa es "1" si ambas organizaciones en la díada comparten intensidad innovadora y "0" si tienen diferentes niveles de intensidad innovadora.

Resultados

Esta sección se organiza en torno a las dos preguntas de investigación propuestas. El primer conjunto de resultados se refiere a las características y propiedades estructurales del intercambio informal de conocimientos GRH. El segundo conjunto examina la relación entre la participación en redes de intercambio y la actividad innovadora de las empresas en materia de GRH.

Propiedades estructurales de las redes de conocimientos de GRH entre empresas

En primer lugar se presenta la visualización de la red examinada y la posición estructural de las firmas dentro de ella (ver Figura 1 y Figura 2). Los nodos representan las empresas individuales y las flechas ilustran el flujo de conocimiento de GRH.

Figura 1. Red colaborativa de intercambio de conocimiento de GRH
(centralidad de grado para tamaño de nodo)

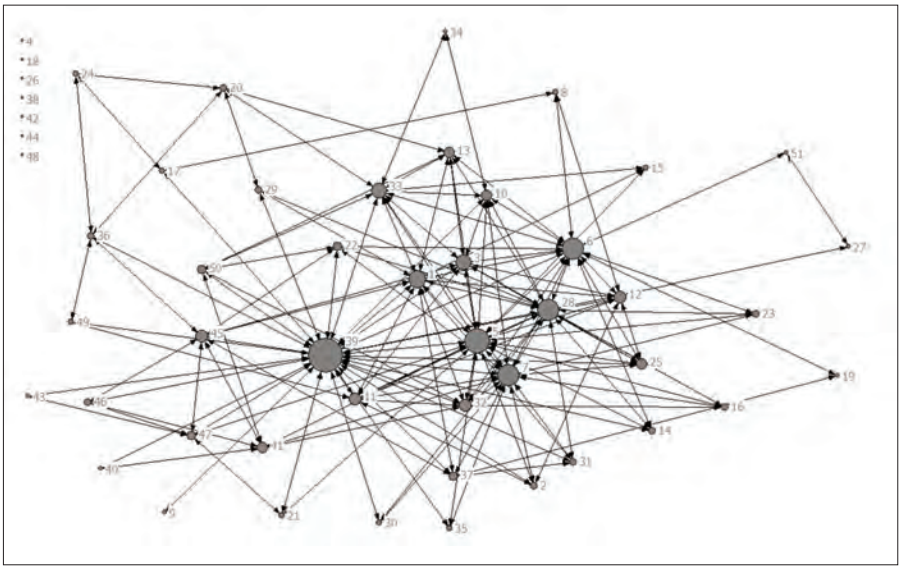
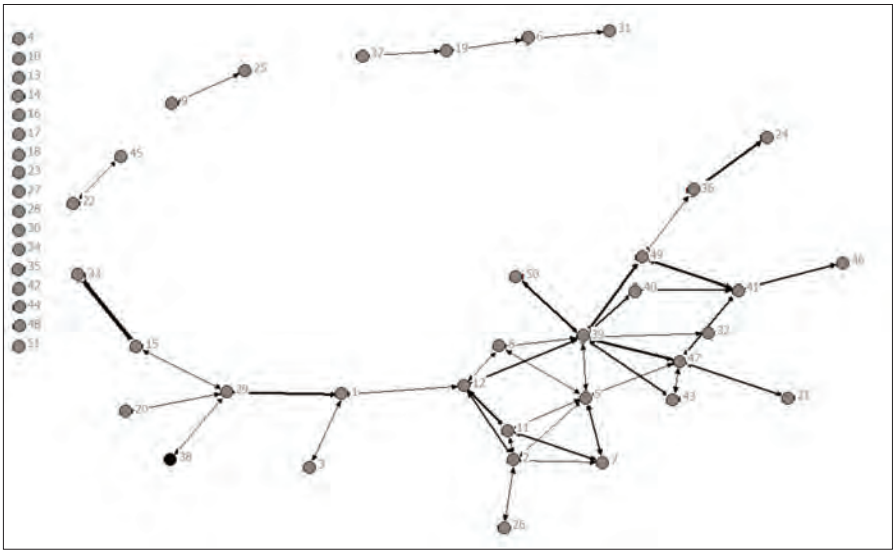


Figura 2. Red formal de intercambio de conocimiento de GRH
(centralidad de grado para tamaño de nodo)



Con respecto a la estructura reticular de las relaciones de intercambio de conocimiento, como se ve en el Gráfico 1, la red revela que las relaciones colaborativas están relativamente consolidadas. Pocas empresas están aisladas del resto de las empresas del parque. La existencia de una red de conocimiento de GRH, posiblemente, puede ser atribuible al hecho de que la mayoría de las empresas en el parque comparten ciertos intereses comunes, al operar en industrias similares (industrias de alta tecnología) y ser similares en tamaño y antigüedad. Sobre la base de nuestro análisis, una observación importante se puede hacer de la red de GRH: las empresas se involucran en relaciones de colaboración que van más allá del intercambio de información sobre aspectos tecnológicos, de mercado o productos (tal y como la literatura ha puesto de manifiesto en diversos estudios) para incluir el conocimiento de GRH. La Figura 2 muestra el sociograma de relaciones formales de intercambio de conocimiento de GRH. En este caso se muestra que determinadas empresas se benefician de la existencia de acuerdos formales con otras organizaciones para intercambiar conocimiento de GRH. Este tipo de intercambios ha sido documentado en la literatura especializada (Martin-Rios, 2014). Por tanto, podemos afirmar que la gran mayoría de las empresas del

estudio participaron en la red de GRH con el fin de obtener información sobre aspectos relacionados con la GRH, respondiendo a nuestra primera pregunta de investigación.

Varios nodos de coordinación son citados con recurrencia. Estos representan las empresas que se sitúan en el corazón de la red y tienen un gran número de vínculos. En ese sentido, la Oficina de Tecnológica es central en la red, aunque no tenga ningún control de los recursos financieros y de personal de las empresas del parque. Su centralidad podría estar relacionado con su papel como proveedor de conocimiento que desarrolla fuertes lazos con la mayoría de las empresas en la red y sirve como intermediario entre los distintos grupos en el intercambio del conocimiento. Para examinar la distribución de las empresas a través de las redes, se calculó el grado de puntos, es decir, el número de conexiones (las relaciones) que una empresa tiene con otras empresas en cada red de conocimiento. Por ejemplo, la empresa 5 es la principal fuente de información en la red. Esta empresa es una de las más antiguas en el parque, participa activamente en la Asociación de Empresas y es reconocida por su tecnología y la innovación organizacional. Otras empresas como la 2, 3, 11 y 46 son muy activas en la red tanto en la recepción como en la difusión de conocimiento de GRH. Hay una gran variación de actores en lo que respecta a la recepción de información (más que para la difusión de la información). Las empresas 1, 7, 11 y 32 son centrales en la recepción de información. Las empresas 7 y 11 son también activas en el intercambio de información y, de alguna manera, actúan como "comunicadores" en la red. En cambio, la empresa 1 recibe abundante información de GRH, pero no transfiere mucha.

A continuación, analizamos los factores los índices de red calculados, incluyendo la densidad, la centralización de la red y la reciprocidad (ver Tabla 2).

Tabla 2. Resultados estructurales de la red

	*Tamaño**	*Nodos aislados*	*Índice centralización (%)*	*Densidad*	*Lazos recíprocos (%)*
Red formal (transaccional)	51	17/51=33.3%	33.35	0.05	28.72%
Red informal (colaborativa)	51	13/51=25.4%	38.69	0.068	21.54%

* Incluyendo la Oficina de Transferencia

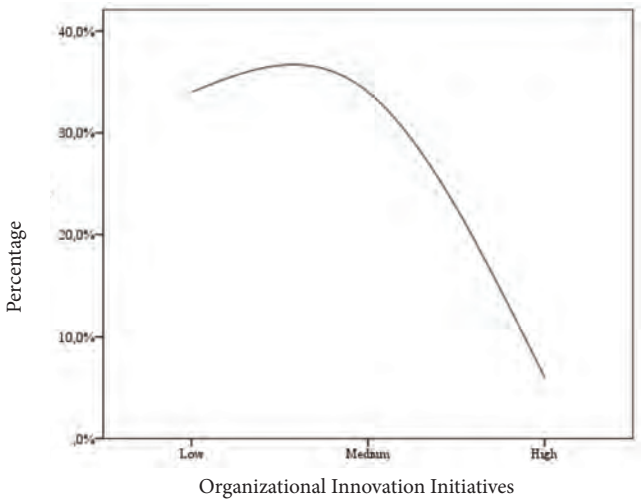
Respecto a la centralización de la red, cuanto más centralizada es la red mayor es el número de empresas en una posición que les permite controlar el flujo de conocimientos. La estructura de ambas redes de conocimiento de GRH es relativamente descentralizada: 38,7% para la red formal (transaccional) y 33% para la red informal (colaborativa). Para calcular la densidad de los flujos de conocimiento entre empresas, se calculó el porcentaje de densidad de cada red. Para la red informal, la medida de densidad tiene el valor de 0,07 y para la red formal 0,05. En base a estos valores, se podría especular que el flujo de conocimiento de baja densidad descansa en una serie de contactos relativamente poco frecuentes y poco estructurados entre un número considerable de empresas. Respecto a las propiedades relacionales (naturaleza de los vínculos) de la red de conocimiento de GRH, el porcentaje de relaciones recíprocas es 21,54% y 29%. De todas las parejas de actores que tienen alguna conexión, el 53% de las parejas tienen una conexión recíproca. Esto podría sugerir una estructuración más bien no-jerárquica de la red de GRH.

La relación entre la red de conocimiento de GRH y la innovación en GRH

La segunda pregunta de investigación propuesta investiga la relación entre la participación de las empresas en redes de intercambio de conocimiento de GRH y la capacidad de innovación en materia de GRH. La literatura en relaciones inter-organizativas muestra la existencia de una relación positiva entre ambos fenómenos en aspectos tales como la innovación tecnológica, la innovación de producto, o la innovación social. Hay, sin embargo, una carencia de estudios que permitan aseverar que la participación en redes de conocimiento de GRH tiene un efecto positivo en la actividad innovadora en GRH.

En este estudio las empresas se clasificaron en función de la mayor o menor intensidad de sus innovaciones en GRH entre las que tenían baja intensidad de innovaciones (menos de un 30%), media (hasta un 60%), y alta intensidad con más de un 61% de innovaciones en GRH en los dos últimos años. La variable resultante está representada gráficamente en la Figura 3 donde se observa que la mayoría de empresas presentan unos niveles moderados de innovación en GRH.

Figura 3. Intensidad de innovación en GRH (porcentaje de empresas en cada nivel)



El análisis de varianza ANOVA permite observar diversas relaciones estadísticamente significativas entre la actividad innovadora y la participación en redes de intercambio (Tabla 3). Por un lado, hay una

relación sólida (sig.+.01) entre la intensidad innovadora alta y la participación en redes tanto formales como informales de intercambio de conocimiento de GRH. Las empresas más innovadoras juegan un papel muy activo en las dinámicas de intercambio inter-organizacionales. Asimismo, se observa una relación positiva (sig.+.05) entre las empresas de intensidad innovadora media y la participación en redes cooperativas o informales de intercambio. Este tipo de empresas optan por obtener conocimiento de GRH a través de relaciones colaborativas más que a través de redes contractuales. Finalmente, hay una relación negativa y significativa entre una intensidad innovadora baja y la participación en redes formales de conocimiento (sig.+.05). Respecto a las redes informales la relación no es estadísticamente significativa. Así, la dirección apunta a que las empresas con menor intensidad innovadora participan poco tanto en redes formales como en redes informales.

Tabla 3. Actividad innovadora y participación en redes de conocimiento (ANOVA).

Participación en redes	Intensidad innovadora de la empresa		
	Baja innovación GRH	Media innovación GRH	Alta innovación GRH
Intercambio formal	(-)*	(-)	(++)**
Intercambio informal	(-)	(+)*	(++)**

* = Sig. 0.05

** = Sig. 0.01

Discusión

El propósito de este trabajo es analizar los factores que determinan el intercambio de conocimiento de GRH y su relación con los niveles de innovación de un grupo de empresas localizadas en un parque científico y tecnológico en España. La principal conclusión alcanzada es que las empresas, a través de sus gerentes y el personal clave en materia de gestión de personas, son conocedoras de la importancia de incorporar conocimiento a partir de fuentes externas; puesto que dicha participación tiene una relación positiva con la introducción de innovaciones en GRH. Esta investigación está guiada por una concepción teórica del intercambio de conocimiento de GRH como un proceso dinámico profundamente enraizado en un sistema complejo de redes de relaciones, donde el establecimiento y el mantenimiento de lazos inter-organizativos tanto formales como informales estimulan el desarrollo de tales intercambios (Sammarra y Biggiero, 2008). Los flujos de conocimiento tienen lugar a través de estos intercambios con los posibles efectos beneficiosos en forma de un mayor esfuerzo innovador en GRH por parte de las empresas participantes y, en última estancia, la formación de ventajas competitivas.

Nuestros resultados ofrecen pruebas preliminares sobre la función positiva que las redes entre organizaciones desempeñan en la difusión de conocimientos relacionados con la GRH. En respuesta a nuestra pregunta de investigación, en qué medida se producen intercambios de conocimiento de GRH entre empresas independientes, nuestra conclusión es positiva. Nuestros hallazgos muestran que la red de conocimiento de GRH empresa a empresa estaba relativamente bien consolidada. En ese sentido, podemos concluir que las empresas objeto de este estudio participan activamente en la difusión y el intercambio de conocimientos de GRH con otras empresas. Los resultados de los análisis sociométricos indican que las empresas ubicadas en el PCT participan en dichas redes con el propósito de obtener acceso a las capacidades de GRH en manos de otras empresas. Como resultado, la red de conocimientos de GRH era relativamente descentralizada y tenía baja densidad, sobre todo es interactiva (en función de la proporción relativamente alta de relaciones recíprocas) dado que la mayoría de las empresas son accesibles a todas las demás. Todo lo cual parece favorecer el intercambio de una cantidad considerable de conocimientos GRH.

Además, el estudio plantea una posible relación positiva entre la participación en redes de conocimiento y la actividad innovadora en GRH. En este sentido, la literatura existente da indicaciones de la posible relación (Martin-Rios, 2014); sin embargo, la carencia de estudios específicos no permiten alcanzar conclusiones respecto a la GRH. En concreto, este estudio apunta a la importancia que las empresas otorgan a adquirir nuevos conocimientos de GRH como uno de los principales motivadores y beneficios para llevar a cabo innovaciones de GRH. Puesto que las competencias básicas de la empresa moderna están ineludiblemente ligadas al conocimiento (Grant, 1996; Martin-Rios y Erhardt, 2017), la cultura innovadora (Erhardt, Martin-Rios y Heckscher, 2016; Erhardt, Martin-Rios y Way, 2009; Parga, Martin-Rios y Criado, 2013) y los sistemas de innovación tecnológica y no tecnológica (Martin-Rios y Pasamar, 2017; Martin-Rios, Pasamar y Gonzalez-Perez, 2016), los flujos de conocimiento son indispensables para promover el aprendizaje organizacional (Martin-Rios y Erhardt, 2017; Septiem y Martin-Rios, 2011). Lo cual permite a la empresa ampliar, mejorar y modificar sus stocks de conocimientos. Y, en definitiva, favorecer el desarrollo de las capacidades dinámicas de la empresa (Teece et al., 1997). En ese sentido, esta conclusión se suma a un debate central en la GRH como fuente de creación de valor (Delery y Doty, 1996), mediante el cual el conocimiento de GRH ofrece oportunidades de aprendizaje e innovación para las empresas (Martin-Rios, 2014). El aprendizaje organizacional es una capacidad fundamental de la organización que se ha planteado como una importante fuente de ventaja competitiva sostenible (Fiol y Lyles, 1985). Las redes entre organizaciones devienen un aspecto destacado en este proceso de aprendizaje (Martin-Rios y Erhardt, 2017). De ello se desprende, que la participación en redes de conocimientos de GRH pueden ser un medio para crear y fomentar una ventaja competitiva.

Una implicación práctica derivada de este estudio radica en la oportunidad que supone para los profesionales de GRH el fomentar el establecimiento de lazos colaborativos con personas externas a la propia organización. De este modo, pueden establecerse lazos informales relacionales, los cuales implican no solo cierta legitimidad, sino también un cierto grado de reciprocidad (Szulanski, 1996). Aprender cómo se propaga la GRH de conocimiento entre las empresas puede dar lugar a formas más eficaces de aprovechar esas corrientes, que pueden contribuir al aumento de las existencias de conocimiento de GRH. Además, el intercambio de las experiencias cooperativas tiene

consecuencias positivas, no sólo para las organizaciones que han obtenido los conocimientos de GRH, sino también para aquellos que comparten información, que pueden lograr una mayor legitimidad y prestigio. Dicha aseveración enlaza con estudios anteriores en la materia. Por ejemplo, Kossek (1987) menciona en su estudio la legitimidad y el prestigio como razones para participar en redes interorganizacionales de las cuales los ejecutivos de la firma son miembros para intercambiar información sobre las tendencias actuales de GRH. Asimismo, Williamson y Cable (2003) sugieren que la legitimidad juega papel preponderante en el establecimiento de relaciones de intercambio: quienes toman las decisiones en las empresas imitan las prácticas que ellos consideran legítimas, dado que han producido resultados positivos para dichas empresas.

Cabe señalar por ultimo diversas limitaciones del estudio. El método que se emplea para evaluar empíricamente dicha relación es el análisis de la varianza ANOVA, el cual posee diversas limitaciones relacionadas con la necesidad de realizar un muestreo aleatorio. Futuras investigaciones deberían utilizar modelos de análisis que faciliten la robustez de los resultados obtenidos. Otros vacíos identificados por los autores constituyen oportunidades de investigación. Por ejemplo, las redes de conocimiento son vitales para las organizaciones como fuente de conocimiento y, por tanto, como un elemento esencial que aporta valor a los objetivos estratégicos de la empresa. Se debería profundizar sobre las motivaciones de los actores implicados en el intercambio de conocimiento para su participación o no en redes colaborativas y las ganancias y perjuicios que se pueden derivar de dicha participación o de su ausencia. Mientras tanto surgen nuevas oportunidades innovadoras alentadas por el intercambio de conocimiento lo que podría indicar que las empresas que tratan de adaptarse a estas transformaciones son capaces de perseverar. Estos aspectos merecen ser considerados en el desarrollo de futuros estudios.

En conclusión, este estudio proporciona un puente entre los teóricos de redes sociales y los teóricos de la GRH al analizar las características y propiedades de los canales de intercambio, a través de los cuales, el conocimiento de GRH se propaga. Si las redes entre empresas son cruciales para el flujo de conocimiento y, por tanto, para el aprendizaje organizacional y la competitividad, este estudio se centra en analizar cuál es la relación existente entre la participación en relaciones de colaboración para aumentar el acceso a los conocimientos GRH y la implementación de innovaciones en GRH. Actualmente sabemos relativamente poco sobre las prácticas de éxito en la gestión del intercambio de conocimientos en la GRH y acerca de las relaciones diádicas entre las empresas que potencialmente mejoran el nivel de colaboración que se necesita para impulsar el intercambio de conocimientos de GRH. Hemos concluido que las empresas participan en tales flujos de conocimiento dada una posible ganancia instrumental: la mejora de sus stocks de conocimiento manteniendo estables los costes de transacción; así como ciertas ganancias relacionales: el establecimiento de relaciones de reciprocidad y la ganancia de legitimidad y prestigio en su entorno.

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ISSN: 0718-2724. (http://jotmi.org)

Mapping impacts of open innovation practices in a firm competitiveness

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Abstract: This manuscript aims to understand how it is possible to improve the competitiveness of a company using open innovation practices and presents evidences that open innovation can be practice, especially regarding technologies adoption and actions involving partnerships and collaboration. The paper concludes, base in a case study of a ICT firm, that even with a partial degree of openness and an intermediate level of maturity, open innovation put into practice have contributed to technological development and increase company competitiveness in its activity sector. It also pointed out challenges in execution capacity, internal process improvements and partnership relations, but mainly challenge is breaking cultural barriers in open innovation implementation. Finally, a set of recommendations were proposed to expand actions based on open innovation management, upgrade innovation maturity level and increase competitive potential of the companies.

Keywords: open innovation; disruptive innovation; competitiveness; ICT.

Submitted: June 30th 2017 / Approved: September 11th 2017

Introduction

Nowadays consumer market is increasingly competitive and many companies have been trying to innovate in products, services and business models in search of a competitive edge. Globalization is already a reality and carries at its core the principle of competitiveness among companies and maximum exploitation of the economic system (Hitt, Ireland and Hoskisson, 2012). Thus, innovation becomes a means to create and maintain sustainable competitive advantages, being considered a key element of business success (Johannessen, Olsen and Lumpkin, 2001). Innovation has been widely discussed in business environment because, due to speed with which business has been transformed in recent years, companies that reinvent themselves and innovate their business models are likely to be those that will sustain themselves in the market in the medium and long term. The idea about innovation is directly linked to the concept of something new, be it transformed into product or service (Bessant and Tidd, 2007).

Merging competitiveness and innovation themes, as well as their correlation, is not a recent study target. At beginning of 20th century, Henry Ford already investigated the modification of production model seeking maximum system efficiency and effectiveness (Maximiano, 2000). Recently, giant companies such as Kodak, even with all its history and technological arsenal, were unable to reconcile their innovative vein with the need for a business model re-evaluation and ended up not stay in the market (Mui, 2012). In contrast, other companies, such as IBM, have repositioned themselves to remain competitive (Harreld, O'Reilly and Tushman, 2007). In parallel to this competitiveness evolution scenario, a innovation management model called Open Innovation (OI) emerged, which can be understood as a model of innovation management based on the use of internal and/or external efforts for the new technologies development (Porto, 2013).

This manuscript proposes to evaluate several issues of innovation environment in a firm and, based on a case study of a Brazilian ICT company, it tries to respond the following question: "Is it possible to improve the competitiveness of an ICT company using open innovation?". Answering this question, it is expected to assist future researches about open innovation and encourage companies to adopt and implement an innovation model more open and collaborative towards a better business competitiveness.

Review

Competitive strategy

The concept of strategy is old and originally military, it was simply a high-level plan to compete and achieve one or more objectives in uncertainty conditions (Freedman, 2015). Strategy can be also defining as a system for finding, formulating, and developing a doctrine that will ensure long-term success if followed faithfully (Kvint, 2010). Therefore, strategy usually involves setting goals, determining actions to achieve goals, and mobilizing resources to perform actions. It also involves activities such as planning and strategic thinking.

In strategic planning, companies must establish their competitive advantages that will enable them to achieve their strategic objectives. Different strategy studies look for ways to guide companies on competitive advantages definition. The classic concept of competitive strategy published by Porter (2008a) still applies today and is applied in several organizations, based on strategies for differentiation, total cost leadership or focus (niche). Even in their most recent studies, Porter (2008b) approach to competitive strategy considers factors that add competitive advantage, such as bargaining per purchasing power, monitoring new entrants and replacing products and services, but does not explicitly consider as essential to competitive strategy.

An alternative approach to competitive strategy is proposed by Prahalad and Ramaswamy (2003) when they point out that the next innovation practices must completely change the way products and services are created and competition between companies. Tidd, Bessant

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and Pavitt (1997) also point out that innovation contributes in several ways to increasing firm's competitive advantage, including research that suggests a strong correlation between market performance and new products insertion.

In this way, it can be observed that researchers share opinions about main variables that can enhance companies' competitive capacity, but it is fact that innovation, directly or indirectly, is an additional ingredient that drives companies to grow and sustain themselves in the market over time. Analyzing effects of innovation on company strategy and performance, for firms that are driven by barriers to entry and customer needs anticipation, innovation skills can help company to guarantee long-term competitiveness (Reed, Storrud-Barnes and Jessup, 2012).

Open Innovation

The discussion about the innovation concept is a recurring theme in several knowledge areas and has been improving recently. Thus, from seminal proposition on innovation as "new combinations" by Schumpeter (1996) which determine economic development, other definitions improve innovation concept and extended the concept of product and process innovation to encompass market and organizational innovations with new business models (Tidd, Bessant and Pavitt, 2008; Oslo, 2005; Hales, 1998). Norman and Verganti (2014) present two innovation dimensions (technology and business model), classifying innovation in four types: Market-Pull, Technology-Push, Meaning-Driven and Technology Epiphanies. Market-Pull innovation builds on existing business models and technologies and is therefore only a form of incremental innovation based on simple market needs. Technology-Push innovation has a semi-radical nature because despite being applied to an already existing business model, it inserts a technology innovation that was previously undeveloped. Meaning-Driven innovation, also categorized as semi-radical, starts from understanding sociocultural aspects and results in new business models with new meanings and values. Technology Innovation Epiphany brings a disruptive (radical) change.

Another way to classify innovations are: product and service innovation, process innovation, position innovation and paradigm innovation (Tidd, Bessant, Pavitt, 1997; Hales, 1998). Basically, product innovation is based on introduction of products or services with the use of new knowledge and technologies or even existing knowledge and technologies. Process innovation refers to introduction of a new process or significant improvements that aims to reduce costs, lead times or improve quality. Position innovation proposes to introduce new marketing methods, involving significant changes in the design, packaging, distribution, promotion or price of the product (Tidd, Bessant, Pavitt, 1997). On the other hand, paradigm innovation, also known as organizational innovation, introduces new business or organizational models whose goals are to improve organizational performance, reduce costs or increase customer satisfaction.

Per results, the innovations can still be classified as being incremental or radical. Incremental innovations can be understood as an adaptation, refinement, or continuous improvement of something pre-existing. On the other hand, radical or disruptive innovations have a discontinuous and highly positive impact, materializing in completely new products and processes with high market acceptance (Freeman and Perez, 2000).

Another relevant characterization concerns innovation management model which can be defined as "closed" or open. Open innovation (OI) is often contrasted with closed innovation where firms generate their own ideas of innovation, and then develop, build, market, distribute, finance and support themselves (Chesbrough, 2006a). Open innovation, on the other hand, proposes to open the entire innovation process of the organization, both to give away ideas and innovations not used as well as to assimilate technologies and external opportunities adhering to the business. Thus, it can be said that open innovation is a broad concept that encompasses different dimensions and with internal and external focus (Mortara et al., 2009).

Most of studies associate open innovation with the processes of intentional knowledge output or input and technology to innovation accelerate processes and to better benefit the innovative efforts (Chesbrough, Vanhaverbeke, 2006; Chesbrough, 2006b). Regarding the technology output process, also known as technology exploitation or inside-out process, Van de Vrande et al., 2009 states that for better use of internal knowledge, companies can engage in various innovation practices. The three activities related to technology output are: venturing, licensing of intellectual property (IP), and involvement of non-R&D workers in innovation initiatives (Chesbrough, 2006a; Van Dijk, Van Den Ende, 2002; Gassmann, 2006; Lichtenthaler, 2007). The technology input process, also called technology exploration or outside-in, refers to the activities that allow companies to acquire new knowledge and technologies outside organization boundaries. Among five main forms related to this technology exploitation are: customer involvement, external network capitalization, external participation, outsourcing R&D and licensing (acquisition) of intellectual property (Van de Vrande et al., 2009; Gassmann, 2006; Von Hippel, 2009).

Open innovation implementation

In a completely open environment, companies combine these two categories of practices: both outside-in and inside-out, to create maximum value from their technological capabilities or other skills (Chesbrough, Crowther, 2006; Lichtenthaler, 2008). This may be the biggest organizations challenge: to make their technological development environments fully open. The concern with usability of innovation management model has already been object of empirical studies in multinationals firms like Lucent, 3Com, IBM, Intel and Millennium Pharmaceuticals (Chesbrough, 2006a).

Other studies on open innovation practice have also been applied to small and medium-sized enterprises (SMEs) and found that this company profile also uses such an innovation management model for market-related reasons such as meeting customer demands or maintaining (Van de Vrande et al., 2009; Lee et al., 2010). Chaston and Scott (2012) analysed performance of companies in Peru in relation to entrepreneurial orientation and involvement in open innovation,

verified a higher sales growth, and indicated a greater confidence in the use of knowledge management through outside-in and inside-out OI processes. Specifically, in Brazil, Ades et al. (2013) analysed open innovation implementation and main results reinforce that cultural issues are the major obstacle to its implementation.

A Nokia case study shows a strategy based on prospecting and collaboration between partner companies through technology cooperation networks, where such networks between companies offer flexibility, speed, innovation and ability to changes in market conditions and new strategic opportunities, which can provide a great competitive advantage (Dittrich and Duysters, 2007). Even in traditional sectors such as telecommunications that mix declines in revenues and high competition level has sought competitive advantage through OI, as is the case of Deutsche Telekom (Rohrbeck, Hölzle, Gemünden, 2009).

Assuming that companies do not become totally adept at OI and often have isolated or sporadic initiatives that foster OI adoption, Ferro (2010) proposed an innovation strategy classification of firms that considers initiatives breadth and insertion of these initiatives into company's business model. This OI strategy can be classified as "full", when firms adopt initiatives for technologies input and output explicitly integrated with business model and systematized in processes and formal routines, or "potential" when firms don't have formalized processes, but that eventually has one or another initiative characteristic of OI. There are two intermediary classification "partial" and "causal", the first one which presents much openness than second one. In order to collaborate in gaps identification for OI implementation, a framework was proposed to measure OI maturity level (Enkel, Bell and Hogenkamp, 2011), combining innovation issues observed in three dimensions: climate for innovation (organization environment), partnership capacity and internal processes. Based on this approach, OI maturity of firms can be classified from initial (L1) to optimized level (L5), which this last level show the highest stage on OI maturity.

Method

This research evaluates qualitatively and exploratory (Malhotra, 2012; Godoy, 1995; Gil, 2002) issues to answer the question if is possible improve competitiveness by implementing open innovation. For this, a literature review was done to get main researches about open innovation implementation. To understand relationship between open innovation and competitive increase, a case study was adopted and it carried out in a deep and systematic way to enable a more comprehensive and detailed understanding (Gil, 2002; Yin, 2015). After literature review, this study was divided into three stages: (i) research protocol planning, (ii) data collection, and (iii) analysis and interpretation.

Stage (i) was for planning research protocol and it followed script based on Freitas and Jabbour (2011): definition of main research question; establishment of the main objective; evaluation of theoretical support themes; evaluation of potential respondents and evidence sources; definition of best period to execution and places of evidence collection; interview script summary.

Data collection (stage ii) was composed of following steps: formal contact with the organization object of study; presentation of research objectives; definition of key people to be interviewed; definition of criteria for access to company and supporting documents; evidence collection through interviews and documentary analysis. Data sources were used organizational reports, semi-structured interviews and direct observation with participation. Five interviewees in depth were held with executive professionals who work in strategic jobs in the company: R&D Specialist (R&D), R&D Manager, Innovation Management Officer, Business Marketing Director and Retail Marketing Director. Survey took place in May and June 2015 at the company headquarter.

Last stage (iii) is about analysis and interpretation of data and evidences collected. This stage consists of examining, categorizing, tabulating and recombining evidences, keeping conceptual model and initial propositions of study as references. It is a highly complex step because there are no specific standardizations for analysis and interpretation of data and evidence for this type of research (Borges, Hoppen, Luce, 2009; Prodanov, de Freitas, 2013). According to Freitas and Jabbour (2011), this step will consist in a reliable transcription of collected data, detailed description of evidences, analysis and interpretation of evidence based on main concepts, cross-evidence between different interviewees and use of content analysis technique (Flick, 2004; Bardin, 2011).

The company object in this case study operates in the information and communications technology (ICT) sector in Brazil over 60 years, has more than 3,000 employees and invoices approximately US$ 600 million per year. Furthermore, it serving customers in different market segments: corporate, micro and small enterprises (SME) and retail in general, having a prominent position in its sector with numerous awards. For confidentiality reasons, company and interviewees names were kept in secret and we will use "Alpha" name when referring to studied company here.

Results

Innovation and organizational strategy

The Alpha company has a strategic planning model based on Balanced Score Card (BSC), implemented through software in which company's strategic objectives are defined according to BSC's perspectives (client, financial, processes and people), contribution boards, as well as performance indicators of each process and internal area. These indicators are monitored weekly by the company's executives, who clearly have a market positioning based on niche and differentiation for quality and service, thus following niche competitive strategy according to Porter (2008b). One of interviewees presented main screen of BSC dashboard, which made it possible to identify that item "innovation" is a strategic objective of the company and must support the strategies of operational efficiency, revenue generation and customer relationships. This aspect was confirmed during the other interviews in which all the interviewees affirmed to be clear that innovation is part of the strategies of the company. According to Tidd,

Bessant and Pavitt (1997), the organization also focuses on its competitive model in variables based on products, prices, suppliers, etc. It also includes innovation as a strategic variable.

Innovation indicators in company's BSC are comprised of new revenues from products under three years old, innovation expenditures and prototype risks. Company has a target of 20% new revenues originated from innovation projects and has reached this percentage in the last, but did not reveal amounts involved. Investments made with innovation have not been opened either, but company makes use of tax incentives and incentives available in its country (Informatics Law, Finep Edicts, CNPq. etc.) to finance initiatives related to innovation such as events, workshops, sponsorships, training, prototypes implementation and other actions to encourage innovation.

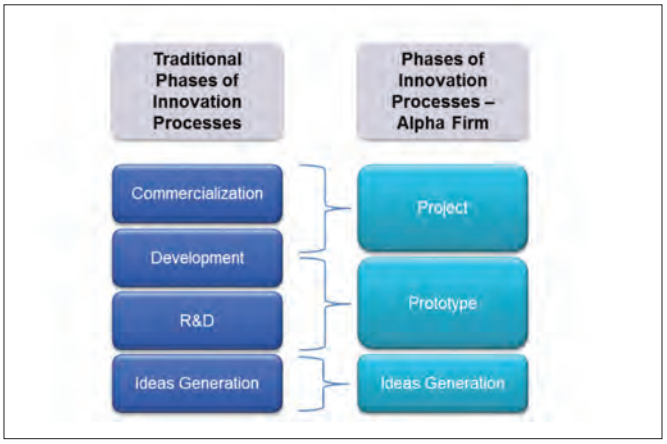
When questioned about OI concepts, it was observed that interviewees from marketing/business areas had a still in-depth knowledge and understanding about this subject. Interviewees linked directly to the innovation process dominate concepts and report that OI-based model should still be better worked and disseminated at all levels of organization.

Open innovation practices

In Alpha company, innovation processes have been working for more than 15 years. Since 2008, company sought support from a consultancy to better structure its internal processes for innovation in phases (figure 1).

Following an adaptation of innovation process traditional stages with aim of making its implementation more practical, Alpha adopts a model in which R&D phases are merged into a phase called "prototype", in which all feasibility studies as well as initial implementation of possible innovation. At this stage, innovation is tested and may incur situations of failure or non-acceptance by market. However, risk and spending up to now are small and not very relevant. Design phase is a mixture of development and commercialization of new technology, since innovation has already been successfully tested as a prototype and is capable of being reproduced on a large scale. At this stage, innovation is already treated as a business project and is now handled by project management standards and methods.

Figure 1. Innovation process phases in Alpha company



Based on this phase model, Table 1 shows a mapping of innovation instruments obtained through interviews, documents and materials available on the web, from which main evidences of possible use of OI, as well as identification of the innovation process phase and whether observed action is applied. In the same table a classification was made of which phase of internal innovation process each observed action applies, GI as generation ideas phase, PT - prototyping phase and PJ as project phase. It was also made a correlation with technologies outside-in and inside-out process commonly observed in open innovation model (Chesbrough, Crowther, 2006; Lichtenthaler, 2008), where inside-out is identified by C, technology outside-in by A and, if action fits in inside-out and outside-in at same time, is identified by CA.

In general, it is observed that Alpha Company has more focused efforts in internal processes of idea generation and prototyping. As far as OI processes are concerned, most of actions and examples are focused on technology outside-in. The "strategic partnerships" and "support structures" actions refer to both open innovations outside-in and open-out processes, as shown in column CA of Table 1. However, such technology inside-out actions are still quite embryonic in Alpha and cannot be considered as technology inside-out in its fullness, as the process in the OI literature is defined.

Also, Alpha presented some few innovation initiatives with customer involvement, external network capture and external participation. However, it has no initiatives regarding project consortium, intellectual property licensing, corporate venture or even spin-outs, which reinforces a relevant limitation in the adoption of OI model.

Table 1. Alpha Innovation Tools Summary

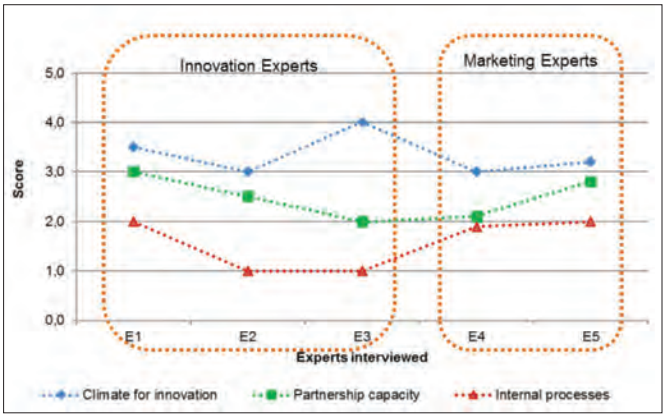
Action	Description	Examples	Open Innovation			Internal Process		
			C	A	CA	GI	PT	PJ
Events and workshops	Participation in internal and external events and workshops focused on innovation and entrepreneurship	Entrepreneurship SP, Startup Weekend, Minas Startup, Innovation Week, Innovation Show, ANPEI		★		★	★	
Executive Forums	Forums where future strategies and innovation are discussed at senior management level	Strategy Review Meeting (RAE) and forums with the participation of specialized consultants		★		★		★
Problem Solutions	Exposure of business and technology problems so that the solution is given by internal and external participants	Hackathons, pitch fights, marathons with internal and external audiences		★		★	★	
HR Development	Planning and implementing actions to develop and / or attract highly skilled young talents	Programming Marathons, Mathematical Olympiads, EADs on internal processes of innovation		★		★	★	
Market Trials	Experimental service offerings	Connected house, IPTV over Gpon, Music MVNO		★			★	★
Strategic Partnership	Establishment of alliances to develop technologies and / or business models	CPqD, Inatel, Nokia, Universities, URI-Erechin, CERTI Foundation, TeleStax, IBM, 100 Open Startups			★	★	★	
Support team	Dedicated structures for planning and developing all innovation processes in the company	IMO (focus on innovation management) and R&D (focus on research and development)			★	★	★	★
Customer Integration	Usage research, trials and visits to customers' environments	Studies based on customer complaints and use of services, field visits to clients and local authorities and forums with opinion formers		★		★		
Joint development	Collaboration with objective of reaching a certain public or market	Connected house, IPTV over Gpon, Music MVNO, MDN		★			★	v

Open innovation maturity level

The challenges pointed out in interviews are directly related to focus and execution capacity. Although we already have some internal areas totally focused on innovation (innovation management and R&D), the company still needs a greater internal alignment regarding the innovation model, mainly open innovation, as well as its main paradigm shifts. According to one of the interviewees: "There is already a very favourable climate for innovation in our company, where people are willing to participate and collaborate, have knowledge and some financial contribution available, because company has been able to build this over time. But for OI practice, it still needs changing mind set at all organization levels.".

In line with innovation maturity dimensions described by Enkel, Bell and Hogenkamp (2011), pro-innovation climate was a consensus point among respondents, but opinions diverged on topics "capacity to forge partnerships" and "internal processes for innovation". In figure 2, each interviewee is identified by codes E1 through E5. Executives whom works directly with innovation process are identified by E1, E2, E3 and professionals E4 and E5 are responsible for marketing and strategy in Alpha.

Figure 2. Dimensions for maturity in open innovation



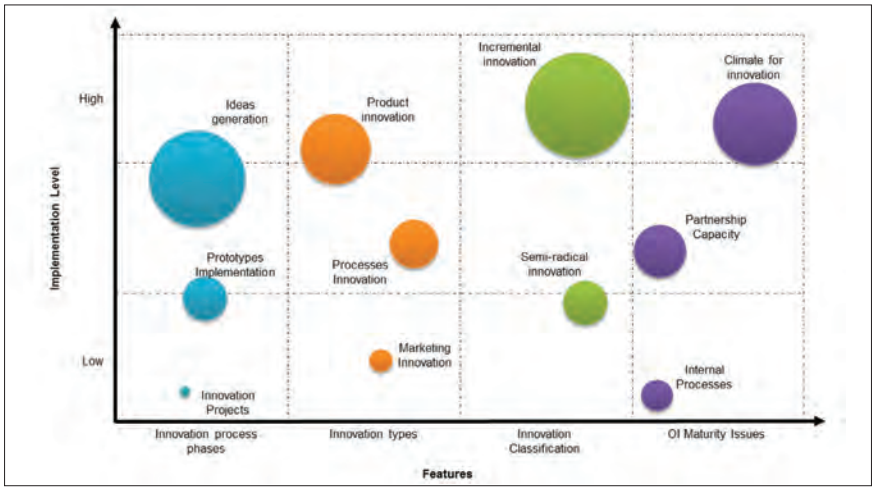
When evaluating a score from 0 to 5, with maximum score means best evaluation, each interviewee can judge Alpha ability to adopt OI as a model of innovation management. Assigned values were focused on average scoring, with a favorable climate for innovation as the best evaluated dimension and internal processes with lower evaluation. It is interesting to note that respondents' evaluations about innovation

processes were more rigorous, possibly because they experienced more recurring difficulties in innovation execution. Median marks given by marketing executives lead to deduction of a possible distance from these areas with processes related to innovation.

Regarding OI implementation challenges, issues related to internal culture were mentioned, where it is necessary to unlink innovation actions from traditional model that Alpha conducts its business, thus giving greater flexibility, openness to risks and stimuli for innovation proposals. Based on these statements, it can be inferred that critical assessment attributed to "internal processes" may be linked to aspects of company's culture that are still based on internal policies and decisions with very short-term visions, low risk appetite and high degree of control and governance. The same confirmation can be made for "establishment of partnerships" that may be limiting in internal culture of being "major shareholder" or "determine final decision". Some of these challenges have already been pointed out by Mortara and Minshall (2011) when they affirm that impulse to adopt OI is strongly related to organizational culture, thus reinforcing the conclusion that top management plays a fundamental role in implementation of OI management model.

Here it is given an overview interviews data collected, visual observations of headquarter on-site visit, as well as documentary surveys carried out during entire period of data collection. Figure 3 shows a characterization based on the interpretation of the obtained data. The size of the bubbles in the graph represents the intensity of the action for each observed characteristic. It is possible to observe in Figure 3 different aspects that characterize the current stage of innovation practice in Alpha company. It is noted that Alpha has a high and medium-high degree of implementation for issues such as idea generation, product innovation, incremental innovations and a good innovation climate. But it has a medium to medium-low implementation level for aspects such as prototyping, process innovation, semi-radical innovation and ability to establish partnerships. Innovation development and commercialization, position and paradigm innovations, disruptive innovations and internal processes have a low implementation degree in Alpha, thus being important pain points to be taken care and worked on internally. This characterization does not denote absence of "closed" innovation or open innovation processes in company studied or that takes merit of actions implemented to date, but points out gaps that need to be worked out if Alpha wants to effectively increase its competitiveness in its market through OI.

Figure 3. Summary of Alpha features according to innovation conceptual classifications



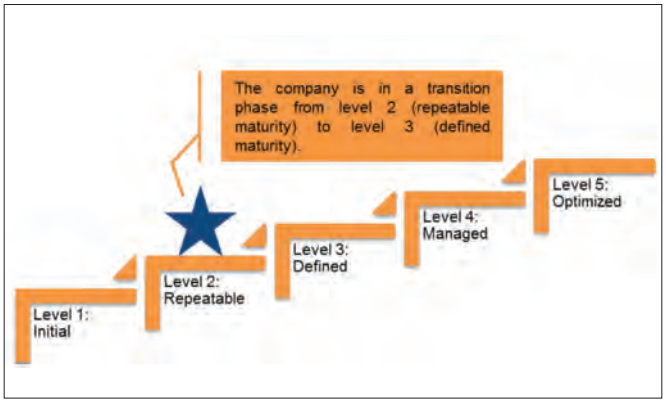
In this study, it was possible to observe that Alpha company has traced an evolution path in value generation through innovation processes. Therefore, it is important to evaluate that Alpha OI management maturity level (Figure 4), which presents classification obtained regarding degree of company's innovation strategy openness.

Figure 4. Open innovation strategy classification for Alpha

It is observed that although it is not explicitly managing its innovation in an open way, Alpha fits as having a partial openness innovation strategy. This means that Alpha has partially formalized OI routines and processes, a possible indication that company is moving towards an OI strategy, but not being able or willing to implement it in its strategy.

Using model proposed by Enkel, Bell and Hogenkamp (2011), Alpha can be classified as "Level 2: Repetitive" in OI maturity and excellence (Figure 5). It shows that company needs to expand aspects such as partnerships, as well as formalization and improvements in internal processes as discussed previously.

Figure 5. Alpha maturity in open innovation



This classification was obtained by average of interviewees evaluations from which a maturity level of 2.5 was reached. Thus, based on data collected, it is observed that Alpha is already initiating a transition process to OI maturity level 3, once one that has in its innovation roadmap initiatives focused on partnerships expansion and establishment of procedures and policies for knowledge and technologies input and output.

Impacts on competitiveness

Since innovation is part of company's strategy and there are some indications of partial OI adoption by Alpha, it is hoped to verify positive impacts on company competitiveness. Table 2 presents some examples of innovations as well as the characterization of it according to Norman and Verganti (2014) and type of impact observed in company's competitiveness.

It was checked that great majority of innovations mentioned by interviewees refer to incremental innovations. In some of them, company established a partnership for innovation development, mostly used its internal R&D as main technology provider. Although there are no links between examples identified with direct OI practices, such innovations have contributed to increase company's competitiveness, either by reducing costs or increasing revenues, per Freeman and Perez (2000). It is also noted that Alpha has some occasional efforts of semi-radical innovation that were also essential to improve company operational efficiency (cost reduction) or to generate new revenues through innovation in business model of mobility services. But neither in interviews and observations made during visit to company headquarter nor in research on complementary documents, no examples of radical innovations were reported or identified.

Table 2. Innovations features and impacts on Alpha competitiveness

Innovation Features	Firm initiatives	Competitiveness impact		Analysis and validation
		Cost Reduction	Revenue Increasing	
Market-Pull innovation (incremental)	Mobile App, IVR, Voice Recorder, TAM, Pre-paid plataform, SVA's, IPTV over Gpon, ICT services	✓	✓	It uses Internal R&D and some partnerships to develop the innovations. However, Alpha uses existing technologies and business models. Predominance of incremental innovation in products and processes.
Technology-push innovation (semi-radical)	Multi-service Plataform	✓	✗	Developed an integrated services platform based on open source that provides numerous services now provided by the company. The example required of R&D for being new technology. The observed case refers to a process innovation with a semi-radical characteristic.
Meaning-driving innovation (semi-radical)	New mobile services	✗	✓	Taking advantage of a legislative guideline, company opted for a business model in one of its services offered to market which allowed it to double customer base in the last two years. Implemented a new business model despite using existing technology, thus characterizing a position innovation.
Technology Epiphany innovation (radical)	Not found	✗	✗	No cases of radical innovation have been observed or reported.

Conclusions

Present study about open innovation and competitiveness aimed to understand in depth the relevance of innovation process to firm's competitiveness, as well as to assess innovation practices adopted by Alpha company. It was observed that Alpha has a formal alignment between innovation and strategy, since innovation is part of organization strategic objectives and it has specific performance indicators that are measured and monitored periodically. Company did not disclose amounts spent on innovation, but main sources of funding for innovation actions come from legal subsidies and national edicts which encourage innovation in Brazil.

Regarding OI practices, Alpha has evolved in recent years its innovation management processes. Although not explicitly using OI, indirect practices have been identified that are focused on technologies absorption through partners, suppliers, universities and technology research centres. OI processes are partially implemented, and technologies output (inside-out OI process) is still at a very embryonic stage in the company. It was also observed that there are limited or non-existent participation initiatives in consortia, licensing of intellectual property, venturing or spin-outs, which potentiates a relevant limitation in practical adoption of OI.

It was also verified positive impacts of innovation actions on Alpha competitiveness. From 2008 to 2013, about US$ 30 million were saved through technological innovations. Most of them were product or process innovations, incremental and developed by internal R&D or with some collaboration from a few partners and universities. In this case, main challenges are to mature open innovation process, giving more focus and execution capacity, as well as refining internal processes and improving partnership relationships. OI implementation challenges should also get attention with aspects related to internal culture, where it is necessary to unlink innovation from Alpha traditional management model, thus allowing greater flexibility and incentives for innovation proposals and partnerships. Possibly limitations found in "partnership capacity" and "internal processes" may be linked to aspects of the company culture.

In general, when looking at innovation practices, Alpha mostly focus on incremental product and service innovations, with limitations on prototypes and projects execution. This characterization does not denote absence of OI processes, but leads to a classification of "partial" opening of innovation processes. Despite this, company has a favourable climate to foster innovation. In another measurement, it was possible to verify that Alpha has a medium maturity level in open innovation, classifying it as "Level 2 - Repetitive". However, it can be said that due to several internal actions in progress, Alpha is in a transition phase to a higher maturity level with greater capacity to establish and manage internal partnerships and processes more closely to needs of OI management model.

In this way, it can be concluded that even with partial OI practices adoption it is possible to develop innovative actions that increase competitiveness such as company studied, but it is up to the company to have the option by open innovation as a strategic pillar and priorities for its implementation. This study case concluded that even with a partial degree of openness and an intermediate level of maturity, open innovation put into practice can support technological development and increase business competitiveness in its activity sector.

In order to assist Alpha and other organizations that are in similar OI management maturity stages, this study makes following recommendations: (i) establish actions focused on the inside-out process through venturing, licensing of intellectual property and Involvement of non-R&D employees in innovation initiatives; (ii) promote collaborative actions with clients and external actors involvement; (iii) establish studies and routines of technology analysis and evolution (technology forecasting); (iv) define an exclusive fund for investment in innovation; (v) establish formal partnerships processes for technological development; (vi) reassess internal processes that allow for greater fluidity of ideas, prototypes and innovation projects implementation in a way that is not linked to the operation and routine of company; (vii) remove radically from organizational culture the myth that nobody cannot make mistakes, but mistakes are allowed if done and revised quickly; (viii) ensure that neither top management nor short-term objectives will interfere in present and future innovation initiatives; (ix) seek initiatives through partnerships, spin-offs, ventures and effectively bring disruptive innovations to the organization.

As limitations, this study should not be generalized because it is a specific case study in a ICT firm. Anyway, it serves as a reference for good practices and how to evolve a company's innovation processes towards open innovation. As future work, other actors of innovation ecosystem such as partners, ICTs and universities can be inserted, in order to widen scope of concepts and practices discussed. In addition, a comparative analysis with firms from other sectors would be relevant and how these have used open innovation in favour of their competitiveness.

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