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Impacts of obstacles on innovation patterns in KIBS firms

Nabil Amara [a,*], Pablo D'Este [b], Réjean Landry [a], David Doloreux [c,d]

[a] Faculty of Business, Laval University, Quebec, QC, Canada
[b] INGENIO, CSIC-UPV, Spanish Council for Scientific Research, Universidad Politecnica de Valencia, Spain
[c] Department of International Business, HEC Montréal, , Montréal, QC, Canada
[d] Kedge Business School, Talence, France

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ABSTRACT

Factors that impede the innovation propensity of manufacturing firms have been under-studied and under-documented. Obstacles to innovation in KIBS firms are literally not documented at all. Based on a sample of Canadian KIBS firms, this study argues that in KIBS firms, the propensity to innovate should take into account not only product and process innovations, but also other forms of innovation (delivery, strategic, managerial, and marketing). Furthermore, we argue that different obstacles will affect different forms of innovation. The results show that, overall, financial obstacles are negatively related to product and process innovations, and that knowledge obstacles tend to be negatively associated with delivery, strategic, managerial, and marketing innovations. These results carry important managerial implications. Hence, managers of KIBS firms might benefit from remembering that a failure to recognize the differences between KIBS firms and manufacturing firms could lead to an inefficient allocation of the resources invested in innovation activities.

1. Introduction

A large and still growing empirical literature investigates the factors that increase the propensity of firms to innovate and the intensity of innovation. By comparison, empirical studies on factors that impede innovation in firms are still very scanty. Improving our understanding of obstacles to innovation is important for theoretical and policy purposes (D'Este, Rentocchini, & Vega Jurado, 2014). First, a better understanding of obstacles to innovation would help improve theories explaining why some firms either do not innovate at all or do not engage more intensively in innovation. Second, providing better evidence would help devising policies to aid firms surmount obstacles, thus increasing the innovation propensity of non-innovative firms or the innovation intensity of innovative firms.

The empirical literature on obstacles to innovation in manufacturing firms can be regrouped in two broad streams of studies. A first stream of research uses obstacles to innovation as dependent variables, and it focuses on the relationship between obstacles to innovation and various firm characteristics (Baldwin & Lin, 2002; D'Este, Iammarino, Savona, & von Tunzelmann, 2012; D'Este et al., 2014; Hölzl & Janger, 2011; Tourigny & Le, 2004). These studies document the importance of financial obstacles for manufacturing firms and show that perceived obstacles are more important for small than large firms, and that more innovative firms are more likely to assess obstacles as important. A second stream of studies uses obstacles as independent variables, and it attempts to show how the propensity to innovate or the innovation intensity is affected by various categories of obstacles (D'Este, Amara, & Olmos, 2016; Mancusi & Vezzulli, 2010; Mohnen & Röller, 2005; Savignac, 2008). The studies of this second stream of research show that financial obstacles have a strong and significant negative effect on the innovation propensity of manufacturing firms. Overall, the results of these two streams of research converge to highlight the importance of financial obstacles in impeding product and process innovation in manufacturing firms.

However, a lack of empirical evidence is still prevalent about innovation in services in general (O'Cass, Song, & Yuan, 2013) and, more particular, about obstacles to innovation in service firms (Thakur & Hale, 2013). This article attempts to fill this gap by looking at a sample of Knowledge-intensive business services (KIBS) firms. The ultimate aim is to show how different obstacles affect the capacity of KIBS to innovate. To do so, we build and extend from the second stream of research on obstacles to innovation in order to argue that in KIBS firms, the propensity to innovate should take into account not only product and process innovations, but also delivery, strategic, managerial, and marketing innovations (den Hertog, van der Aa, & de Jong, 2010). Furthermore, we argue that different obstacles will affect different forms of innovation.

The rest of the article is organized as follows. Section 2 reviews prior studies on the variety of forms of innovation likely to emerge in KIBS firms and factors increasing/hampering their innovation propensity. Section 3 deals with methodological issues, including data collection and descriptive statistics regarding obstacles to innovation. Section 4

* Corresponding author at: Faculty of Business, Laval University, Quebec, QC G1V0A6, Canada. Tel.: +1 4186562131x4382; fax: +1 4186562624.
E-mail addresses: nabil.amara@mng.ulaval.ca (N. Amara), pabdescu@upvnet.upv.es (P. D'Este), rejean.landry@fsa.ulaval.ca (R. Landry), david.doloreux@hec.ca (D. Doloreux).

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introduces the analytical plan and the statistical results regarding the influence of different types of obstacles on different forms of innovation. The last section briefly summarizes the results, and discusses implications for the management of innovation in KIBS firms.

2. Prior studies on innovation and obstacles in KIBS firms

2.1. On the definition of KIBS

According to Doloreux and Shearmur (2010: 611), "KIBS refers to establishments that are characterised by high knowledge intensity and that offer predominantly non-routine services to their clients." KIBS combine various types of highly specialized knowledge in order to develop (either innovative or non-innovative) problem-specific solutions (Koschatzky & Stahlecker, 2006; Muller & Zenker, 2001). Miles (2008) proposed a working definition of KIBS that distinguishes between "professional service firms" (P-KIBS) and "technical service firms" (T-KIBS). P-KIBS provide traditional professional services based on specialized knowledge of administrative systems and social affairs (e.g., business and management services, legal accounting and activities, market research, etc.), while T-KIBS provide services mainly concerned by information and communication technologies, as well as by the production and transfer of knowledge regarding technology (e.g., IT-related services, R&D services; engineering services). Some sub-sectors of activities providing services and displaying high levels of qualified labor and of use of new technologies are usually not considered as KIBS (e.g., agriculture, forestry, mining, and gas extraction) (Muller & Doloreux, 2009).

2.2. The multifaceted forms of innovation in KIBS firms

Prior studies on obstacles to innovation have focused on technological innovations. However, it is now widely recognized in the literature that service innovation cannot be reduced to technological innovations (Hidalgo & D'Alvaro, 2014; Vang & Zellner, 2005). Consequently, the *assimilation approach*, which rests on the idea that innovation in services is similar to innovation in manufacturing industries, is more and more discarded (Bryson & Monnoyer, 2004; Drejer, 2004).

The *demarcation approach* contends that service innovation is distinctively different from innovation in manufacturing, and then, new definitions and new measures need to be developed in order to capture the particularities of the non-technological dimensions of innovation in services (Doloreux & Shearmur, 2010; Tether, Hipp, & Miles, 2001; van der Aa & Elfring, 2002). Consequently, many researchers on service innovation called for the development of a *synthesis approach* that would integrate the two previous approaches (Amara, Landry, & Doloreux, 2009; Drejer, 2004). Such an approach offers two significant advantages. First, it takes into account technological innovations and thus, allows comparisons between innovation in manufacturing and service industries. Second, by integrating the demarcation approach into a new synthesis one, it allows the integration of technological and non-technological dimensions of innovation into a single perspective that is likely to shed new light on the multidimensional facets of innovation.

In this article, we adopt the synthesis approach to build and extend from prior studies in order to differentiate two technological and four non-technological forms of service innovation (Amara et al., 2009; den Hertog, 2002; Howells & Tether, 2004; OECD, 2006; Sundbo & Gallouj, 2001; Tether et al., 2002).

Product and process innovations represent technological forms of innovation, while delivery, strategic, managerial, and marketing innovations represent non-technological forms of innovation that largely overlap with organizational innovations since they represent various dimensions of organizational innovations.

We hypothesize that different forms of service innovation will be influenced by different types of obstacles. These six forms of service innovation are operationally defined in Table 1.

2.3. Explaining the different forms of service innovation and the influence of their obstacles

KIBS firms provide services based on professional knowledge. In a knowledge-intensive industry, transactions consist of knowledge and outputs that are often intangible. Innovations result more often from new combinations of knowledge rather than from new combinations of physical artefacts (O'Cass & Sok, 2013; Rubalcaba, Michel, Sundbo, Brown, & Reynoso, 2012). Hence, the core competence of KIBS resides in their capability to combine, in a new unique body of knowledge, codified scientific and technical knowledge with tacit knowledge based on extensive experience to "help other organisations deal with problems for which external sources of knowledge are required" (Miles, 2005, p. 39). Similarly, Leiponen (2006, p. 444) claims that KIBS "...almost exclusively consist of transferring knowledge and skills to clients' organisations". In such a context, we postulate that, contrary to manufacturing firms, KIBS' innovation capabilities are likely to be less hampered by financial obstacles than by knowledge obstacles. Building and extending from this rationale, we articulate the independent variables of this study around three categories: knowledge factors that contribute to increase innovation propensity, knowledge and financial factors that hamper innovation propensity, and control factors.

2.3.1. Knowledge factors that contribute to increase innovation propensity

In the literature on innovation and knowledge management, four categories of knowledge assets are considered important to explain the innovation propensity of firms: the variety of knowledge sources, knowledge creation, knowledge embodied in managerial practices and advanced technologies, and knowledge embodied in the strength of ties.

Variety of knowledge sources. The importance of external sources of knowledge used in the innovation process occupies a central place in studies on open innovation (Amara & Landry, 2005; Dahlander & Gann, 2010; Gassmann, Enkel, & Chesbrough, 2010; Laursen & Salter, 2006; Lee, Park, Yoon, & Park, 2010). Innovative firms increasingly rely on

Table 1
Descriptive statistics.

Dependent variable: types of innovation	Description: *During the last three years, did your business unit …*	% within types of innovation (*N*)
• Product innovation	introduce onto the market any new or significant improved products (goods or services)?	59.7 (*671*)
• Process innovation	introduce any new or significantly improved production processes?	29.5 (*332*)
• Delivery innovation	implement changes in how the enterprise delivers its products (goods or services) to its customers?	52.4 (*589*)
• Strategic innovation	Implement new or significantly modified business strategies?	54.9 (*617*)
• Managerial innovation	implement new or significantly modified managerial techniques?	42.9 (*482*)
• Marketing innovation	implement new or significantly modified marketing strategies and concepts?	43.0 (*483*)

Note: The total number of observations is 1124.

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these external knowledge sources as a way of accessing the knowledge available outside their boundaries (Chesbrough, 2003). In prior studies, distinctions have often been made between three categories of external sources of information that are likely to positively influence firms' innovation performance, namely, market, research, and generally available sources of information (Shearmur & Doloreux, 2013; Vega-Jurado, Gutiérrez-Gracia, Fernández-de-Lucio, & Manjarrés-Henríquez, 2008) (see Appendix A for the complete list of external sources of information considered in this study, as well as their operational definitions). Based on this rationale, we hypothesize the following:

H1. Enhancing the variety of market, research, and generally available sources of information contributes to increase the likelihood of all six forms of innovation in KIBS firms.

Knowledge creation. In-house R&D contributes to create knowledge which, in turn, fosters new combinations of old and new knowledge that helps to develop or improve services or ways of producing, marketing or delivering them (Amara et al., 2009; Leiponen, 2006). Hence, one can hypothesize the following:

H2. KIBS firms that conduct R&D are more likely to develop all six forms of innovation.

Knowledge embodied in managerial practices and advanced technologies. Knowledge management practices embody knowledge that facilitates the emergence of new combinations of old and new knowledge that, in turn, increase the likelihood of innovation (Amara et al., 2009; Landry, Amara, Lamari, & Ouimet, 2007). Likewise, firms' learning capabilities are also enhanced by the use of advanced technologies that embody codified knowledge, which creates new opportunities for experimentation and problem solving that would be otherwise impossible (Madsen & Desai, 2010; Magazzini, Pammolli, & Riccaboni, 2012). Based on this rationale, we hypothesize the following:

H3. Increasing the use of knowledge management practices and advanced technologies could contribute to increase the likelihood of developing the different forms of innovation.

Knowledge embodied in the strength of ties. Knowledge is also embodied in the ties that KIBS firms forge with their clients (Amara, Landry, Halilem, & Traoré, 2010). Prior studies stress the benefits of weak ties – distant relationships – to identify and explore non-redundant information about new ideas and innovation opportunities (Granovetter, 1983), as well as the benefits of strong ties – close relationships – to facilitate the transfer and exploitation of (validated) knowledge, encourage joint problem-solving capabilities, and create opportunities for operational support (Coleman, 1988). These two hypotheses will be tested empirically in the present study.

H4. Weak and strong ties with main clients contribute to increase the likelihood of developing the different forms of innovation.

2.3.2. Factors that hamper innovation propensity

Prior empirical studies, which investigate the role of obstacles in the innovation process, largely highlighted (1) the determinants of perception of the importance of barriers to innovation (Baldwin & Hanel, 2003; Galia & Legros, 2004; Iammarino, Sanna-Randaccio, & Savona, 2009) and (2) the impact of barriers, mainly financial barriers, on the propensity to innovate and/or the degree of novelty of innovation (Mancusi & Vezzulli, 2010; Mohnen, Palm, van der Loeff, & Tiwari, 2008; Savignac, 2008). For their part, D'este et al. (2012) approached, in a very different way, this question by distinguishing between *revealed* and *deterring* barriers to innovation. The revealed barriers interpretation contends that "engagement in innovation activity increases firms' awareness of the associated difficulties (i.e., increases consciousness and knowledge of the factors constraining innovation through the 'disclosing' or 'learning' outcome of direct experience), although it does not prevent them from engaging in innovation activities or being successful innovators" (D'este et al., 2012: 483). From the deterring barriers perspective, obstacles are interpreted as inducing deterring effects on firms' innovation activities.

Finally, other studies distinguish between internal and external obstacles to innovation. According to Thakur and Hale (2013), service firms may encounter many important internal and external obstacles. Internal obstacles are generally associated with difficulties to implement internal changes in their managerial and organizational practices (e.g., firm's lack of skilled personnel, lack of management training in innovation management, and cultural rigidness to change). By contrast, external obstacles to innovation (e.g., lack of financing, cost of innovation, long pay-back period, lack of skilled personnel) may arise when KIBS firms acquire resources and knowledge from external sources (Thakur & Hale, 2013).

This study builds primarily on the contributions of D'Este et al. (2012), and Thakur and Hale (2013) to distinguish between three groups of external obstacles to innovation in KIBS firms, namely, financial obstacles, knowledge obstacles, and market obstacles (see Appendix A for the complete list of obstacles to innovation considered in this study, as well as their operational definitions).

Financial obstacles. The first group of obstacles refers to financial obstacles associated with problems regarding financial risk, cost of financing innovation, and access to financing innovation projects. Studies on obstacles encountered by manufacturing firms all point to the importance of financial obstacles as a factor that is negatively associated with product and process innovations (D'Este et al., 2012; Mancusi & Vezzulli, 2010; Savignac, 2008).

In this study, we assume that developing product, process, and marketing innovations is more likely to rely on the use of external capital than delivery, strategic, and managerial innovations, which are more likely to rely on the use of internal resources. Based on this rationale, we hypothesize the following:

H5a. Financial obstacles are likely to negatively influence the propensity of KIBS firms to generate product, process, and marketing innovations.

H5b. Financial obstacles are likely to have no influence on delivery, strategic, and managerial innovations.

Knowledge obstacles. The second group of obstacles encountered by KIBS firms is related to knowledge. In knowledge-intensive business service industries, innovation results from the capability to combine, in a new unique body of knowledge, tacit with codified knowledge, old with new knowledge, and internal with external knowledge (Amara et al., 2009; Anand, Gardner, & Morris, 2007; Miles, 2005). We suggest that the capability to combine in new ways these different types of knowledge might be hampered by the lack of access to skilled employees, lack of information on markets, and lack of information on technologies. More specifically, we hypothesize the following:

H6a. Lack of access to skilled employees is negatively related to all six forms of innovations.

H6b. Lack of access to information on markets is negatively related to strategic and marketing innovations.

H6c. Lack of information on technologies is negatively related to process, delivery, strategic, and managerial innovations.

Market obstacles. The third group of obstacles refers to the intensity of competition (Dean, Brown, & Bamford, 1998; D'Este et al., 2012). The intensity of competition can be related to many factors such as

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the ease with which clients can substitute their products for products of competitors, the constant threat created by the arrival of new competitors, the constant threat created by the arrival of competing products, the rapid obsolescence of products, and the rapid changes of production technologies. We hypothesize the following:

H7. The intensity of competition is negatively related to product, process, delivery, and marketing innovations but has no influence on strategic and managerial innovations.

2.3.3. Control variables

Based on prior studies, we include a number of control variables in the analysis, namely, number of employees (Greve, 2003; Lhuillery & Pfister, 2009), age (Becheikh, Landry, & Amara, 2006), and industry (Amara et al., 2009; Miles, Kastrinos, Flanagan, Bilderbeek, & den Hertog, 1995).

3. Methodology

3.1. Data collection

This study is based on the results of a study entitled "KIBS and regional innovation systems in Canada". The data used in this study have been collected by a survey firm, which conducted computer-assisted telephone interviews from January 30 to May 17, 2007. The questions on the dependent and explanatory variables are derived from the methodology of the Oslo Manual (OECD, 2005) and from the literature on innovation in services. The survey was administered to the population of 5694 KIBS firms that operate in the province of Québec, Canada. A random sample of 2291 firms was drawn for this study. The resulting sample available for interviews was therefore 1612 firms. In the end, 1142 firms completed the interview questionnaire for a response rate of 70.84% (for more detailed information about the survey, see Doloreux, Amara, & Landry, 2008).

An analysis of early versus late respondents' answers to key variables of the study was also performed (Miller & Smith, 1983; Radhakrishna & Doamekpor, 2008). The results of this analysis indicate that the early respondents sub-sample does not differ from the late respondents sub-sample. Hence, we can conclude that non-respondents are perhaps similar to late respondents, and thus the non-response bias is not a major concern in our sample.

3.2. Descriptive statistics

Table 1 presents the distribution of KIBS firms with regard to the different types of innovation. It can be seen that 671 firms (59.70%) indicated that they developed or improved their products, 332 (29.50%) indicated they developed or improved their process of production, 589 firms (52.40%) indicated they introduced delivery innovations, 617 (54.90%) strategic innovations, 482 (42.9%) managerial innovations, and finally 483 firms (43%) indicated they introduced marketing innovations. The descriptive statistics of the different types of obstacles to innovation are presented in Table 2, whereas the descriptive statistics of the other explanatory variables used in this study are reported in Appendix A.

3.3. Analytical models

The following model is developed to see what the determinants of the various types of innovation are, and to see, particularly, in what ways the obstacles to innovation affect these types of innovation:

$$\begin{aligned}\text{Log}\,(P_i/1-P_i) = {} & \beta_0 + \beta_1\text{MRKTS} + \beta_2\text{RESS} + \beta_3\text{INFOS} + \beta_4\text{SrR\&D} \\ & + \beta_5\text{TECHN} + \beta_6\text{PRACT} + \beta_7\text{TIES} + \beta_8\text{ECRISK} \\ & + \beta_9\text{COSTF} + \beta_{10}\text{ACCESSF} + \beta_{11}\text{SKILL} + \beta_{12}\text{INFMRKT} \\ & + \beta_{13}\text{INFTECH} + \beta_{14}\text{COMPET} + \beta_{15}\text{LnSIZE} \\ & + \beta_{16}\text{LnAGE} + \beta_{17}\text{BININDUS}\end{aligned}$$

where

β_i $(i = 0 \ldots 18)$ are the coefficients, and

Log $(P_i / 1 - P_i)$ is, for each type of innovation, the logarithm of the ratio of the probability that a KIBS firm innovates relative to the probability that it does not innovate.

Appendix A provides the overview of the operationalization for the independent variables.

The correlation matrix linking the independent variables used in the regression models, (Appendix B), as well as the tolerance statistic values in first columns of Appendix B ensure that there is no multicollinearity concern (Field, 2013).

3.4. Regression results

The regression results of the logit models are summarized in Table 3. The computed value of the chi-square statistics for each of the six logit regressions is greater than its critical value (i.e., 33.41) with 17 degrees of freedom at the 1% level. All the models are thus significant at the 1% level. The explanatory power of the models, such as indicated by the percentages of correct predictions, is also good. It varies between 65.10% for the marketing innovation's model and 72.40% for the process innovation's model. Finally, the Nagelkerke pseudo R^2 is quite acceptable for models with qualitative dependent variables. It varies between .161 for the marketing innovation's model and .280 for the delivery innovation's model.

Table 2
Frequency of obstacles to innovation.

Over the past 3 years, please rate the importance of the following problems and obstacles to innovation in your firm?						
	Not important at all	Low importance	Moderate importance	High importance	Very high importance	Average (*Median*) [a]
	In % of KIBS firms (number of faculty members)					
Financial obstacles						
• High financial risk	23.3 (*262*)	13.5 (*152*)	22.7 (*255*)	23.6 (*265*)	16.9 (*190*)	2.97 (*3*)
• Cost of financing	30.3 (*340*)	12.8 (*144*)	22.6 (*254*)	22.4 (*252*)	11.9 (*134*)	2.73 (*3*)
• Access to financing	32.6 (*367*)	11.4 (*128*)	20.5 (*230*)	21.1 (*237*)	14.4 (*162*)	273 (*3*)
Knowledge obstacles						
• Lack of access to skilled employees	27.6 (*310*)	6.8 (*76*)	16.5 (*186*)	26.2 (*295*)	22.9 (*257*)	3.10 (*3*)
• Lack of information on markets	35.0 (*393*)	14.3 (*160*)	27.0 (*304*)	15.8 (*178*)	7.9 (*89*)	2.47 (*3*)
• Lack of information on technologies	40.3 (*453*)	17.3 (*194*)	23.5 (*264*)	13.4 (*151*)	5.5 (*62*)	2.26 (*2*)
Market obstacles						
• Intensity of competition	35.8 (*403*)	13.8 (*155*)	26.5 (*298*)	17.3 (*194*)	6.6 (*74*)	2.45 (*3*)

[a] Average and median are calculated on 1 to 5 scale.

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Table 3
Estimated logit models of factors affecting the types of innovation.

Independent variables	Product innovation		Process innovation		Delivery innovation		Strategic innovation		Managerial innovation		Marketing innovation	
	Coeff. (β)	Marginal Impact	Coeff. (β)	Marginal Impact	Coeff. (β)	Marginal Impact	Coeff. (β)	Marginal Impact	Coeff. (β)	Marginal Impact	Coeff. (β)	Marginal Impact
Intercept	−1.365***		−2.043***		−2.770***		−2.261***		−2.702***		−1.919***	
Factors increasing innovation propensity												
Variety of external knowledge sources												
• Market sources of information [MRKTS]	−.077	–	.038	–	.261**	.89	.061	–	.212***	3.41	.141**	2.44
• Research sources of information [RESS]	.108**	.90	−.060	–	−.094	–	−.056	–	−.105	–	.026	–
• Generally available sources of information [INFOS]	.048	–	.021	–	−.103	–	.278***	3.45	.067	–	.156**	2.29
Knowledge creation												
• Percentage of revenue dedicated to R&D activities [*SrR&D*][a]	1.309***	2.33	1.031***	3.64	.447***	.89	.864***	1.83	.577***	1.56	.518***	1.43
Knowledge embodied in managerial practices and technologies												
• Number of advanced technologies used [TECHN]	.069**	1.33	.023	–	.058**	1.26	.126***	2.78	.025	–	.142***	4.09
• Number of knowledge management practices used [PRACT]	.096***	1.12	.129***	3.11	.260***	3.92	.105***	1.54	.198***	3.73	.118***	2.19
Knowledge embodied in strength of ties												
• Strength of ties [TIES]	.277	–	−.578**	−1.31	.324*	.84	.364**	1.01	.220	–	−.102	–
Factors hampering innovation propensity												
Financial obstacles												
• High financial risk [ECRISK]	−.261***	−.68	−.236**	−.45	−.236**	−.65	−.076	–	−.093	–	−.134	–
• Cost of financing [COSTF]	−.281**	−.53	−.334**	−.66	−.125	–	−.057	–	−.009	–	−.290**	−.61
• Access to financing [ACCESSF]	−.263***	−1.48	−.184	–	−.126	–	.030	–	−.029	–	−.210	–
Knowledge obstacles												
• Lack of access to skilled employees [SKILL]	−.029	–	−.004	–	−.247**	−.63	−.020*	−.39	−.176**	−.48	−.501***	−1.31
• Lack of information on markets[INFMRKT]	−.035	–	−.054	–	−.093	–	−.260**	−.64	−.335**	−.78	−.280*	−.79
• Lack of information on technologies [INFTECH]	−.061	–	−.534***	−1.13	−.016	–	−.429**	−1.05	−.328**	−.79	−.157	–
Market obstacles												
• Intensity of competition [COMPET]	−.109	–	−.451***	−.83	−.377**	−.82	−.164	–	−.075	–	−.212**	−.53
Control variables												
• Number of employees [LNSIZE][b]	.081**	.55	.111**	1.42	.231***	2.31	.092*	.96	.172***	2.03	−.073	–
• Business age [LNAGE][b]	−.082	–	−.013	–	.156**	.080	.105	–	.064	–	−.157**	.020
Services Industries												
• Industry [BININDUS]	−.150	–	.282**	.60	−.024	–	−.532***	−1.38	−.015	–	−.105	–
Number of cases: $N = 1107$												
Chi-square (*df*):	215.67 (*17*)		149.17 (*17*)		260.79 (*17*)		197.89 (*17*)		167.69 (*17*)		141.38 (*17*)	
Nagelkerke R^2 (Pseudo *R* Square):	.239		.179		.280		.219		.189		.161	
Percentage of correct predictions:	70.7		72.4		69.7		67.6		66.4			

[a]Elasticities and marginal impacts are reported for a 10% increase in the different explanatory variables.
[a] Sr indicates a square-root transformation.
[b] Ln indicates a logarithmic transformation.
* The coefficient is significant at the 10% threshold.
** The coefficient is significant at the 5% threshold.
*** The coefficient is significant at the 1% threshold.

3.4.1. Factors that increase innovation propensity

Results in Table 3 indicate that between 7 and 10 independent variables are significant from the 1% to the 10% level in the six models corresponding to the various types of innovation considered in this study. More precisely, R&D (SrR&D) and the number of knowledge management practices (PRACT) are found significant and exert a positive impact on the six types of innovation considered in this study. The number of employees (LnSIZE) is found to have a positive and significant impact on the likelihood of developing all types of innovation, except for marketing innovation. As for the number of advanced technologies used (TECHN), it is found significant and exerting a positive effect on the four models referring, respectively, to product innovation, delivery innovation, strategic innovation, and marketing innovation.

With regard to the variety of external knowledge sources used by KIBS firms, the results show that the markets sources index (MRKTS) is significantly and positively related to delivery innovation, managerial innovation, and marketing innovation. Likewise, the research sources index (RESS) exerts a significant and positive impact only on the likelihood that KIBS firms develop product innovation. Finally, the generally available information sources index (INFOS) is significantly and positively related to strategic innovation and marketing innovation.

With regard to the strength of ties (TIES) between KIBS firms and their most important clients, the results indicate that firms which established strong ties rather than weak ties with their most important clients are more likely to introduce delivery innovation and strategic innovation. However, those firms are less likely to develop process innovation.

Furthermore, firms operating in a technology-based industry rather than in a traditional professional industry (BININDUS) are more likely to develop process innovation and less likely to introduce strategic innovation. Finally, the business age of the KIBS firm (LnAGE) is significantly and positively related to delivery innovation, and significantly and negatively related to marketing innovation.

3.4.2. Factors that hamper innovation propensity

With regard to the different groups of obstacles to innovation, the results reported in Table 3 show that, overall, the financial obstacles seem to be considered more important by KIBS firms when they engaged in the development of product innovation and process innovation, whereas the knowledge obstacles are considered more important when KIBS firms engaged in the other four types of innovation. More precisely, KIBS firms are less likely to develop product innovation when they perceived that their innovation activities are threatened by a high financial risk, considered that the cost of financing innovation activities is a barrier of high importance or very high importance, and when the lack of access to financing represented a highly important or very highly important problem. Likewise, KIBS firms are less likely to develop process innovation when they perceived high financial risk, cost of financing, lack of information on technologies, and intensity of completion as obstacles of high or very high importance. As for the likelihood that KIBS firms develop delivery innovation, it decreases when they perceived high financial risk, lack of access to skilled employees, and intensity of competition as obstacles of high or very high importance. The likelihood that KIBS firms develop strategic innovation or managerial innovation decreases when the degree of importance they granted to the lack of access to skilled employees, lack of information on markets, and lack of information on technologies, as obstacles to innovation activities, increases. Finally, the likelihood that KIBS firms introduce marketing innovation decreases when the degree of importance they granted to cost of financing, the lack of access to skilled employees, lack of information on markets, and intensity of competition, as obstacles to innovation activities, increases.

3.5. Results regarding the impact of the significant explanatory variables

To assess the scope of the impact of the explanatory variables that significantly explain the magnitude of the dependent variables, we estimate their marginal effects by using NLOGIT 3.0, Econometric Software Package (see Green, 2002).

As Table 3 shows, for product innovation, the marginal effect of the variable R&D takes the highest value, .233. This implies that a positive relative change of 10% in the percentage of revenue dedicated to R&D activities increases the likelihood of developing product innovation by 2.33%. The two following variables with the highest positive marginal effect on the likelihood of developing product innovation are the number of advanced technologies used (1.33%), and the number of knowledge management practices (1.12%). By contrast, access to financing (−1.48%), and high financial risk (−.68%) have, respectively, the highest negative marginal effect on the likelihood of developing product innovation.

For process innovation, the two highest positive coefficients are those of R&D (3.64%) and the number of knowledge management practices used (3.11%), while the two highest negative coefficients are those of the strength of ties (−1.31%), and the lack of information on technologies (−1.13%).

For delivery innovation, the two highest and positive coefficients correspond to the variables number of knowledge management practices used (3.92%) and number of employees (2.31%). Furthermore, the two highest and negative marginal impact coefficients correspond to the variables intensity of competition (−.82%), and high financial risk (−.65%).

For strategic innovation, the generally available sources of information index, and the number of advanced technologies used, have the two highest and positive coefficients (3.45%, and 2.78%, respectively), whereas industry, and lack of information on technologies, have the two highest and negative coefficients (−1.31%, and −1.05%, respectively).

For managerial innovation, the number of knowledge management practices used, and the market sources of information index show the two highest and positive coefficients of marginal effect (3.73%, and 3.41%, respectively). However, the lack of information on technologies (−.79%) and the lack of information on markets (−.78%) show the two highest and negative coefficients of marginal effect (−.79%, and −.78%, respectively).

Finally, for marketing innovation, the two highest and positive marginal impact coefficients correspond to the variables number of advanced technologies used (4.09%), and the market sources of information index (2.44%), whereas the two highest and negative marginal impact coefficients correspond to the variables lack of access to skilled employees (−1.31%), and the lack of information on markets (−.79%).

4. Discussion and conclusion

The results of this study show that KIBS firms engage in different forms of innovation and that the obstacles encountered by KIBS firms vary from one form of innovation to another. First, we showed that KIBS firms very actively engage both in technological (product and process innovations) and non-technological forms of innovation (delivery, strategic, managerial, and marketing innovations). Second, the results of this study reveal that, overall, financial obstacles are negatively related to product and process innovations, and the knowledge obstacles tend to be negatively associated with delivery, strategic, managerial, and marketing innovations. Finally, the results regarding the marginal impact of the factors that were statistically significantly related to innovation indicate, overall, that the marginal impacts of the knowledge obstacles on delivery, strategic, managerial, and marketing innovations are comparable or higher than the marginal impacts of the financial obstacles on product and process innovations.

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What do these results suggest regarding the management of innovation in KIBS firms? Managers of KIBS firms who lay too much emphasis on the financial obstacles may be led to ignore or misperceive how important other obstacles are, like the lack of access to skilled employees or the lack of information on advanced technologies. Moreover, the results of this study suggest that the managers of KIBS firms have to take into account that the different types of external obstacles tend to differently hamper the various forms of innovation in KIBS firms. Managers of KIBS firms might benefit from remembering that contrary to manufacturing firms where financial obstacles are considered as the most important obstacles to innovation, knowledge obstacles seem to be more important for the non-technological innovations developed by KIBS firms.

The results of this study carry limitations that future research should try to remediate. Hence, this article did not investigate the importance and impact of internal obstacles on the innovation propensity of KIBS firms. Future studies should attempt to shed light on the impact of these internal obstacles. A study on the impact of external obstacles to innovation provides insights on innovative firms but does not provide any evidence on obstacles encountered by non-innovative firms. Future questionnaires on innovation in KIBS firms should include questions on obstacles met by non-innovative firms. Finally, like most studies on innovation, this study surveyed a national population of KIBS firms. Hence, the managerial and policy implications derived from our results need to be interpreted in the context of a national innovation system that may involve specificities that call for caution before making inferences for other national innovation systems.

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Appendix A. Definitions of explanatory variables and descriptive statistics

Continuous variables	Description		Mean	SD	Min	Max
Percentage of revenue dedicated to R&D activities [SrR&D]	Measured as the percentage of the total revenues of 2006 that the firm dedicated to R&D activities. This variable was matched with the normal distribution using a square root transformation.		9.20	19.45	0	100
Number of employees [LNSIZE]	Measured by the total number of full-time employees in 2006. This variable was matched with the normal distribution using a logarithmic transformation.		19.66	49.00	1	500
Business age [LNAGE]	Measured as the number of years between 2007 and the year of creation of the firm. This variable was matched with the normal distribution using a logarithmic transformation.		14.56	12.12	0	97
Market sources index [MRKTS][a]	Measured as an index on a Likert scale of importance ranging from 1 = not important to 5 = very important of the role played between 2004 and 2006 by the following four research organizations as sources of information needed for the firm's innovation activities: (Cronbach $\alpha = .598$)	• Suppliers of software, hardware, materials, or Equipment • Clients • Consultancy firms • Competitors	2.92	.89	1	5
Research sources index [RESS] [a]	Measured as an index on a Likert scale of importance ranging from 1 = not important to 5 = very important of the role played between 2004 and 2006 by the following five market organizations as sources of information needed for the firm's innovation activities: (Cronbach $\alpha = .870$)	• Universities • Colleges • Governmental research laboratories • Research institutions • Centers for technology transfer	1.81	.96	1	5
Generally available information index [INFOS] [a]	Measured as an index on a Likert scale of importance ranging from 1 = not important to 5 = very important of the role played between 2004 and 2006 by the following four generally available sources of information for the firm's innovation activities: (Cronbach $\alpha = .691$)	• Professional conferences, meetings, journals • Trade fairs and exhibitions • Trade associations • Internet	2.97	.93	1	5
Number of advanced technologies used [TECHN]	Measured as a variety index assessing the number of different advanced knowledge management technologies currently used by the firm. Thus, the degree of use of advanced technologies is measured by the sum of the affirmative responses to the following 10 assertions:	• LAN: local area network • Intranet • Internet site • Broadband communications • Groupware software • Software of statistical analysis • Data warehousing/data mining software • System of management of the documents • Data-processing networks for data bases with the clients • Knowledge bases	5.01	2.62	0	10

Categorical variables	Number of code "1"	% of code "1"
Obstacles to innovation		
Dichotomous variables:- Coded "1", if the firm rated the importance of the following obstacles which slowed down or caused problems when the firm developed new or improved services as high importance or very high importance, and 0 otherwise (not important at all; low importance; moderate importance):		
Financial obstacles:		
• High economic risk [ECRISK]	465	41.4%
• Cost of financing [COSTF]	387	34.4%
• Access to financing [ACCESSF]	399	35.5%
Non-financial obstacles:		
• Lack of access to skilled employees [SKILL]	552	49.1%
• Lack of information on markets [INFMRKT]	267	23.8%
• Lack of information on technologies [INFTECH]	213	19.0%
• Intensity of competition [COMPET]	268	23.8%

(continued on next page)

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Appendix A (*continued*)

Categorical variables	Number of code "1"	% of code "1"
Strength of ties [TIES]		
Dichotomous variable:		
- Coded "1" (strong ties), if the firm described its working relationship with its most important clients as very close, (practically like being in the same work group) or somewhat close (like discussing and solving issues together), and 0 otherwise (weak ties) (somewhat distant, like with people that you do not know well; distant, like a working group with which you can only have a quick exchange of information; or very distant, practically like with people that you do not know at all).		
• Strong ties	1030	91.6%
• Weak ties	94	8.4%
Services industries [BININDUS]		
Dichotomous variable:		
- Coded "1" if the firm is operating in a technology-based KIBS (architectural, engineering, and related services; specialized design services; scientific R&D; and computer system designs and related services), and 0 if the firm is operating in a traditional professional KIBS (legal services; accounting, tax preparation, bookkeeping, and payroll services; management, scientific, and technical consulting services; advertising and related services; and other KIBS).		
Traditional professional KIBS:	*513*	*45.6%*
• Legal services	30	2.7%
• Accounting, tax preparation, bookkeeping, and payroll services	35	3.1%%
• Management, scientific, and technical consulting services	273	24.3%
• Advertising and related services	76	6.8%
• Other KIBS	99	8.8%
New technology-based KIBS:	*611*	*54.4%*
• Architectural, engineering, and related services	218	19.4%
• Specialized design services	84	7.5%
• Computer system designs and related services	278	24.7%
• Scientific R&D	31	2.8%

[a] The unidimensionality of constructs with multiple-item scales was assessed by conducting a principal components factor analysis for each construct, which results indicate that the unidimensionality criterion was satisfied. Likewise, the Cronbach α values indicate that the items forming each index are reliable.

Appendix B. Correlations between continuous explanatory variables

	Tolerance statistics[a]	MARKET	RESEAR	INFOR	TECHN	PRACT	LNSIZE	LNAGE	SrR&D
MARKET	.671	1	.459	.482	.077	.152	.118	−.023	.032
RESEAR	.713		1	.372	.039	.099	.232	.035	.100
INFOR	.711			1	.190	.177	.109	−.073	.094
TECHN	.624				1	.502	.457	.071	.260
PRACT	.625					1	.497	.118	.156
LNSIZE	.440						1	.352	.109
LNAGE	.841							1	−.060
SrR&D	.912								1

[a] All the tolerance statistic values are much higher than .2. This ensures that there is no multicollinearity concern (Field, 2013).

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