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Absorptive Capacity and Firms' Generation of Innovation: Revisiting Zahra and George's Model

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Absorptive Capacity and Firms' Generation of Innovation: Revisiting Zahra and George's Model [1]

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Abstract

The firm's absorptive capacity triggers its propensity to capture external knowledge, spurred by internal levers and cooperation liaisons, stimulating innovativeness. This paper revisits Zahra and George's model of absorptive capacity and others, analysing the firm's internal and liaison factors that affect its absorptive capacity, in order to predict their influence on innovation. Being the firm an open system, managers acknowledging such effects can design a more efficient open innovation business model in order to generate more innovation. We analyse firm-level internal indicators measuring firm's absorptive capacity and a set of liaison factors, using a Portuguese sample of 571 service firms and 562 manufacturing firms that participated in the European Community Innovation Survey (CIS), 2010. Results reveal that internal R&D, acquisition of external R&D, acquisition of external knowledge (i.e., equipment, software, licenses and employee training) affect firms' generation of innovation, according to the different sub-samples, which provides several implications for science and innovation policy.

JEL Classification: M20; M21; L25; L26; O32

Keywords: *Absorptive Capacity; Innovation; Liaisons; Internal and External Knowledge*

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1. Introduction

The study of firms' absorptive capacity, addressing a set of firm-level enablers that ease the assimilation of external knowledge and their strategic cooperation relationships, has neglected the contrast between manufacturing and service firms. This paper aims to assess the role played by firms' absorptive capacity and their cooperation strategies in fostering innovativeness in highly turbulent and competitive environments. As stated by Forfás (2005), it is important to understand how firms access new knowledge by establishing and successfully exploiting collaborations with other firms and institutions, having to manage their internal capability to search, detect, access and assimilate this new information embodied in external stakeholders. To do so, we contrast the results obtained, using two sub-samples of manufacturing and service firms.

Several authors analysed the concept of a firm's absorptive capacity as a set of capacities that the firm develops in order to be able to detect external sources of knowledge, assimilate it and use it strategically for generating innovation. These refer to the firm's internal capacities plus organizational learning capacities, such as R&D and human capital (Cohen and Levinthal 1989; 1994; Narula 2004, Giuliani and Bell 2005), qualified human resources (Rothwell and Dodgson 1991; Mangematin and Nesta 1999; Vinding 2004), the acquisition of knowledge (Lundvall and Johnson 1994; Rosenkopf and Nerkar 2001; Johnson et al. 2002; Vinding 2000, 2004), or employee training (Delaney and Huselid 1996; Koch and McGrath 1996).

When assimilating knowledge from outside, SMEs have been using strategic alliances with external stakeholders, by establishing coopetion liaisons when dealing with emerging technologies (Brandenburger and Nalebuff 1996; Gomes-Casseres 1996; Harbison and Pekar 1998). Other authors also focused on the benefits of cooperation and coopetition, the latter being a mix between cooperation and competition (Bagshaw and Bagshaw 2001; Garraffo 2002; Chien and Peng 2005; Rusko 2011).

Previous studies focused their attention on large and knowledge-intensive firms (for instance, Cohen and Levinthal 1989; 1990), with recent work showing growing interest in SMEs' networks with external organisations in order to minimize the lack of internal knowledge (Lundvall and Johnson 1994; Brouwer and Kleinknecht 1997; Gottardi 2000; Johnson et al. 2002; Vinding 2000, 2004). This assumes a key role in developing absorptive capacity.

This article contributes to the empirical literature on research and development (R&D) management by adopting a different perspective from prior work and complementing earlier studies impacting on science and innovation policy design. It deepens understanding of firm-level absorptive capacities, defining the firm's knowledge base, namely internal and complementary factors plus firms' cooperation liaison factors and their innovation pathway. In addition, it considers two control variables, firm size and the sector of economic activity. A logit analysis is performed with 571 service firms and 562 manufacturing firms, from the data available in the CIS 2010, for Portuguese firms.

The remainder of this article is structured as follows. Section 2 develops the theoretical underpinnings, drawn from the literature on firms' absorptive capacity and the relation with firms' innovativeness. Section 3 presents the empirical approach and Section 4 presents and discusses the results. Finally, the article concludes, presenting limitations, possibilities for further research, implications for policy-makers and guidelines for practitioners engaged in managing science and innovation.

2. Theoretical background and hypotheses

2.1. Firms' absorptive capacity and innovation

As approached by Cohen and Levinthal (1990) and Cohen et al. (2002), absorptive capacity refers to the identification of valuable knowledge in the environment, the firm's capacity to assimilate and align it with existing knowledge stocks and finally to exploit it in internal R&D activities to achieve successful innovation.

The firm's capacity to acquire external knowledge depends on its ability to detect where and how this exists, and how to assimilate it into its own corporate structure. Rosenkopf and Nerkar (2001) draw attention to accessing and exploiting external knowledge in distant technological areas. The acquisition of tacit forms of knowledge is an important lever of the firm's absorptive capacity (Lundvall and Johnson 1994; Johnson et al. 2002; Vinding 2004).

Zahra and George (2002) analysed the concept of absorptive capacity as something dynamic, creating a model of the components, antecedents, contingencies and outcomes of absorptive capacity. Their model was innovative because they substituted the component of 'recognizing the value' with 'acquisition' and relocated the influence of appropriability regimes. In addition, these scholars extended the model with the transformation concept that follows the assimilation component, activation triggers and social integration mechanisms, and divided absorptive capacity into 'potential' absorptive capacity and 'renewed' absorptive capacity. The transformation process gives firms the capacity to develop changes in existing processes to be able to absorb new knowledge, assimilating it by means of interpretation and comprehension within existing cognitive structures.

Zahra and George (2002) defend that prior knowledge, e.g. the firm's experience, is fundamental for developing absorptive capacity, but other factors, namely external knowledge sources and complementary external knowledge, are also important. The same was detected by Van den Bosch et al. (1999)'s conceptualization, which used the organizational form and combinative capability construct, and thus pointed to firms' ability to absorb external knowledge being modelled by a set of mechanisms associated with their organizational structure. The settlement of such organizational structures also depends on environmental conditions.

Regarding that statement, Todorova and Durisin (2007) proposed that firms cannot transform their knowledge assets when they are not able to assimilate them.

Zahra and George (2002) distinguish between potential absorptive capacity and realised absorptive capacity. The former has to do with acquisition and assimilation of new external knowledge by reconfiguring the resource base and deploying capacities, while the latter deals with transformation and exploitation of new external knowledge by developing new products and processes. Potential absorptive capacity without realised capacity does not produce an effect on the firm's competitive advantage.

In addition, the same authors identified the activation triggers, social integration mechanisms and appropriability regimes acting as key contingencies. Activation triggers correspond to events or conditioning situations that stimulate or restrict a firm's capacity and intention to use the acquired knowledge. Social integration mechanisms help to lower the barriers between assimilation and transformation, increasing absorptive capacity, which is understood in the proposed model as a dynamic capacity involving a set of organizational routines (e.g. social interactions) and processes. Regimes of appropriability have to do with the firm's ability to secure the competitive advantage achieved from its absorptive capacity. For instance, a strong regime of appropriability is secrecy, where imitation costs are high and extremely difficult due to the non-existence of 'knowledge spillovers' to competitors.

Vega-Jurado et al. (2008) built another model based on Zahra and George (2002), which comprises two main blocks: one dealing with the different dimensions or components of absorptive capacity and the other focusing on the determinants or antecedents of this capacity. The first block has to do with the multidimensional nature of absorptive capacity and the division into potential and renewed absorptive capacity. The second block including organizational knowledge, formalization and social integration mechanisms are determinants (firm's internal factors) of the firm's absorptive capacity. The authors defend that if external knowledge is applicable and in general obtained by other firms/industry sources, it will be easier for the firm to acquire it and exploit it successfully, without too much effort being needed in terms of scientific and technological expertise.

The same authors added one important element to this model, based on theories of organizational learning and technology transfer (Zander and Kogut 1995; Lam 1997; Chen 2004), namely the applicability of relevant knowledge available in the environment, this being a moderating factor of the effects of antecedents on firms' absorptive capacity.

On the contrary, if external knowledge is not so applicable, in general achieved via universities, laboratories, public research institutes or technology institutes, it will be more difficult to acquire and exploit such knowledge, and the firm must develop specific skills to be able to assimilate it efficiently.

Vega-Jurado et al. (2008)'s model differs from that of Zahra and George (2002), in the sense that the latter uses social integration mechanisms as drivers to lower the barriers between assimilation and transformation, affecting only the dimension of renewed absorptive capacity. Vega-Jurado et al.'s model defends that social integration mechanisms and formalization affect all components of absorptive capacity, either positively or negatively.

According to Nelson and Winter (1982), March (1991), Nerkar and Roberts (2004), Miller et al. (2007) and more recently Heras (2014), in order to successfully exploit business opportunities, firms must refine and extend existing technologies, by exploring, that is, learning or acquiring new external knowledge.

The ability to learn and absorb depends on the capacity for evaluating external knowledge (Van den Bosch et al. 1999; Zahra and George 2002). According to Rothaermel and Alexandre (2009), the greater the firm's absorptive capacity the greater its ability to fully capture the benefits resulting from flexibility in technology sourcing. Furthermore, the ability to recognize and exploit knowledge flows varies from one firm to another, resulting in unequal benefits, acting as a competitive advantage.

H_1: The firm's acquisition of external sources of knowledge has a positive and significant effect on generating innovations.

H_{1a}: The firm's external acquisition of R&D has a positive and significant effect on generating innovations.

H_{1b}: The firm's acquisition of other external knowledge has a positive and significant effect on generating innovations.

H_{1c}: The firm's acquisition of equipment, software and licenses has a positive and significant effect on generating innovations.

This absorptive capacity varies according to the firm's existing enablers, such as the knowledge stock embedded in its processes, human capital and products. The importance of the firm's human capital and its role in fostering the generation of innovations has also been studied by several authors, namely, Cohen and Levinthal (1989; 1994), Narula (2004) or Giuliani and Bell (2005).

For instance, Cohen and Levinthal (1989; 1990) drew attention to the need for the firm to be able to exploit external knowledge, which is conditioned by its level of prior knowledge, involving basic skills, shared language and the most recent scientific or technological developments. For Giuliani and Bell (2005), these skills can be shaped through the level of education and training of the firm's human resources and subsequent ability to absorb and exploit external knowledge (skills, training, experience, etc.).

In addition, several authors also focused on the prediction effect of the firm having qualified human resources and its capacity to absorb external sources of knowledge (Rothwell and Dodgson 1991; Mangematin and Nesta 1999; Vinding 2004). Accordingly, Vinding (2000, 2004) defends that formal education, work experience, the organizational set-up and closer relationships with external and internal actors are important drivers of the firm's absorptive capacity. The author argues that highly educated and technically qualified staff tends to be faster and more willing to assimilate and transform available external knowledge (Vinding, 2000).

Studying the importance of potential absorptive capacity for innovation performance, also using the CIS survey, Fosfuri and Tribó (2008) defend that firms with R&D employees who do not publish in scientific journals, are more prone to ignore the potential of using specialized journals which are sources of a great amount of knowledge.

In the same line, Vega-Jurado et al. (2008) argue that if a firm has more employees with higher education qualifications, it will be more likely to establish links with universities and access their knowledge bases in order to be more innovative. Thus:

H_2: The firm's employees having higher education have a positive and significant effect on generating innovations.

Regarding skills development of the human capital inside the firm in order to stimulate its capacity to detect, absorb and exploit external knowledge and thus generate innovation, alternative sources of learning, namely learning by doing and learning by using (Malerba 1992), are of major importance for developing absorptive capacity. Employees' training in areas related to creativity and innovation may reveal an important effect on firms' absorptive capacity and on innovativeness (Delaney and Huselid 1996; Koch and McGrath 1996).

As Zahra and George (2002) defend, the ability to learn and absorb depends on the capacity to value external knowledge.

Learning was also analysed by several authors as a means of exploring new external knowledge, and for the firm to be able to exploit successfully external sources of knowledge, employees must acquire skills and capacities for absorbing new knowledge (Nelson and Winter 1982; March 1991; Nerkar and Roberts 2004; Miller et al. 2007; Heras 2014).

H_3: Employees' training in areas related to innovation activities has a positive and significant effect on generating innovations.

Several scholars (Zahra and George 2002; Todorova and Durisin 2007; Rothaermel and Alexandre 2009; Kostopoulos et al. 2011) analysed the impact of detecting process innovations and introducing them, on the firm's behaviour in generating innovations, referring to architectural innovation and embracing R&D positioning.

Vasudeva and Anand (2011) studied firms facing technological discontinuities and their use of alliance portfolios to gather knowledge flows. They subdivided absorptive capacity into 'latitudinal' and 'longitudinal' components. The former corresponds to the use of diverse knowledge and the latter is distant knowledge. Their findings suggest that a firm with a moderate latitudinal absorptive capacity, equivalent to medium diversity in its portfolio, has a high propensity towards optimal use of knowledge.

As Cohen and Levinthal (1989) argue, the firm's knowledge base plays the role of both absorption and innovation, since its tendency to assimilate external knowledge creates an incentive to invest in R&D. Gambardella (1992) also states that firms with better in-house R&D programmes are abler and prepared to absorb external scientific information.

The positive and significant impact of firms' investment in R&D activities performed inside the firm has also been the subject of multiple studies, such as those by Stock et al. (2001), Cassiman and Veugelers (2006) and Li (2011). These authors outline the major importance of the firm investing in its basic R&D intensity, and of increasing the performance of its in-house R&D. Thus, the following hypothesis is derived:

H_4: The firm's internal R&D activities have a positive and significant effect on generating innovations.

2.2 Firms' cooperation liaisons and innovation strategies

Innovation is an effect of the existing knowledge, either located inside the firm or in the external environment, a firm's absorptive capacity being of major importance to be able to detect and assimilate existing outside opportunities that are powerful for inducing externalities. Such externalities can be explored by establishing links and cooperation agreements with other firms and organisations, and the positive impact on innovation has been analysed by authors such as Freeman (1991; 1994), Jaffe (1989) and Cohen et al. (2002), studying the impact of cooperation links between universities and research centres and firms, between suppliers and end users (Lundvall 1988; Sako 1994; and Shaw 1994) or among competitors (Coombs et al. 1996).

Several authors analysed the determinant role of the firm's absorptive capacity in exploiting the alliances it establishes (Arora and Gambardella 1994; Zahra and George 2002). In this line, having a corporate R&D strategy makes the firm more likely to deal with coopetition relations and get involved in open innovation (Enkel et al. 2009). In addition, strategic management of the firm's knowledge stock is important in order to achieve benefits and obtain competitive advantage (Grindley and Teece 1997).

Zahra and George (2002)'s model addresses activation triggers, social integration mechanisms, and appropriability regimes acting as contingent/moderating factors of antecedents, components and outcomes of absorptive capacity. The present analysis is especially interested in the effect of social integration mechanisms, which intend to reduce the gap between potential absorptive capacity and renewed absorptive capacity, thus fostering efficiency and efficacy.

Belderbos et al. (2004) analysed the relationship between cooperative R&D and firm performance, focusing on the gains for the firm's competitiveness originating in efficiency improvements.

As stated by Ritala and Hurmelinna-Laukkanen (2009), achieving higher absorptive capacity increases the pace of engaging in coopetition and enables innovativeness.

Brandenburger and Nalebuff (1996) consider coopetition as an alternative way to perform in business, as distinct from competition, strategically used by firms that deal with emerging technologies in innovation networks. The studies by Brandenburger and Nalebuff (1996), Dussauge et al. (2000), Tether (2002) and Enkel et al. (2009) deal with the association between firms' innovative capacity and the coopetition and cooperation arrangements they enter to generate value added and increase productivity.

Garraffo (2002) studied the establishment of strategic cooperation arrangements with competitors in firms dealing with emerging technologies.

Several authors point out that the main benefit derived from collaboration between competitors is the creation of completely new products (Tether 2002; Quintana-Garcia and Benavides-Velasco 2004).

Vega-Jurado et al. (2008) defend that it is easier for firms to absorb external knowledge from industry partners than from R&D stakeholders, as most firms have no structure or human resources highly skilled at assimilating and exploiting scientific knowledge of a less applicable nature.

Rusko (2011) defends that one of the main motivations for firms engaging in strategic cooperation arrangements is based on the creation of greater value or benefit, in order to improve economic performance. Thus, we hypothesise that:

H_5: The firm's cooperation liaisons with other firms have a positive and significant effect on generating innovations.

The importance of network links between firms and the scientific community in generating firms' innovative performance has warranted the attention of several researchers, for example Jaffe (1989), Cockburn and Henderson (1998), Cohen et al. (2002), Kostopoulos et al. (2011), Li (2011) and Vasudeva and Anand (2011), studying the impact of cooperation links between universities, research centres and firms. From the previous statements, we formulate the following hypothesis:

H_6: The firm's cooperation liaisons with other R&D stakeholders have a positive and significant effect on generating innovations.

H_{6a}: The firm's cooperation liaisons with consultants have a positive and significant effect on generating innovations.

H_{6b}: The firm's cooperation liaisons with universities have a positive and significant effect on generating innovations.

H_{6c}: The firm's cooperation liaisons with laboratories have a positive and significant effect on generating innovations.

2.3 Proposed Conceptual Model

Taking the literature review on absorptive capacity as a reference and revisiting the model of Zahra and George (2002), a conceptual model is proposed to analyse the relationships between the firm's generation of innovation and a set of determinant factors related to its absorptive capacity. This aims to reveal the importance of absorptive capacity and of cooperation relationships between the firm and external sources of knowledge in fostering the firm's innovativeness.

So drawing from both models, we propose an alternative that revisits Zahra and George's (2002) model and integrates Vega-Jurado et al. (2008)'s vision, using both facets of absorptive capacity, potential and renewed, and dividing potential absorptive capacity into firms' internal factors and their liaison factors.

The first group deals with factors related to firm-level internal elements and complementarity, such as the acquisition of external R&D, other external knowledge or equipment, software and licenses, and internal capacities, such as skills and human capital qualifications, namely, employees' level of education, training in innovation-related areas given to employees and internal R&D activities carried out in the firm.

The second group deals with cooperation liaisons to acquire external knowledge from industry (other firms) or scientific stakeholders (consultants, universities or laboratories).

The model proposed in Fig. 1 presents the conceptual model for firms' absorptive capacity and innovation generation, where the variables related to firms' internal factors of potential absorptive capacity are hypothesized, namely: (H1): The firm's acquisition of external sources of knowledge/complementarity has a positive and significant effect on generating innovations; (H1a): The firm's external acquisition of R&D has a positive and significant effect on generating innovations; (H1b): The firm's acquisition of other external knowledge has a positive and significant effect on generating innovations; (H1c): The firm's acquisition of equipment, software and licenses has a positive and significant effect on generating innovations; (H_2): Employees being university graduates has a positive and significant effect on generating innovations; (H_3): Employees' training in areas related to innovation activities has a positive and significant effect on generating innovations; (H_4): The firm's internal R&D activities have a positive and significant effect on generating innovations.

To assess firms' liaison factors we hypothesize: (H_5) The firm's cooperation liaisons with other firms have a positive and significant effect on generating innovations; and (H_6): The firm's cooperation liaisons with other R&D stakeholders have a positive and significant effect on generating innovations; (H_{6a}): The firm's cooperation liaisons with consultants have a positive and significant effect on generating innovations; (H_{6b}): The firm's cooperation liaisons with universities have a positive and significant effect on generating innovations; (H_{6c}): The firm's cooperation liaisons with laboratories have a positive and significant effect on generating innovations.

[Insert Figure 1 About Here]

3. Method

3.1 Sample, data and model

The present paper aims to assess the role played by the firm's absorptive capacity in its generation of innovations, especially by contrasting service and manufacturing firms, through the analysis of firms' internal and liaison factors. Therefore, using the data available in the European CIS Survey, 2010, we gathered data for Portuguese firms, to which access was granted by the National Institute of Statistics.

The data available is used to produce a sample with 1133 firms, i.e., 562 manufacturing firms and 571 service firms. Using these sub-samples allows us to contrast the generation of innovations in service and manufacturing firms by assessing the role played by absorptive capacity and cooperation relationships.

After determining that both sub-samples are statistically valid, they are submitted to a logistic regression, in order to estimate the probability associated with the different determinant factors of firms' absorptive capacity and their innovative behaviour.

The use of a logistic regression is justified in modelling binary outcome variables. Binary data are very common among the several types of categorical data and their modelling is part of the category of linear regression models (McCullagh and Nelder 1989). This technique is suited to analysing the relation between a categorical or qualitative outcome variable and one or more predictor variables (Peng and So, 2002). The logistic regression model is the most common (Agresti 1996), since it facilitates substantive interpretation of parameters and predicts the probable locations of point events that have not yet been observed. In addition, the dataset was treated in order to avoid missing data, by excluding data blocks with missing values, as a logistic regression is not able to handle this kind of data (Zhang et al. 2014).

Thus, a logistic regression model for the product innovation of service and manufacturing firms is used, considering binary independent variables where ε_k represents the residual term. The estimation process is based on the maximum likelihood procedure and takes into consideration the following model specification:

$$\mathrm{Prod\_inno\_F_i} = \beta_0 + \beta_1 \mathrm{ACF_{1j}} + \beta_2 \mathrm{CoopRel\_F_{2m}} + \varepsilon_k \quad (1)$$

where: *Prod_inno_F*$_i$ = Generation of innovations in firms; *ACF*$_{1j}$ = Absorptive Capacity of firms; *CoopRel_F*$_{2m}$ = Cooperation Relationships established between firms; ε_k = Error term. where: *i=1,…,1133firms*; *j=1,…,6;* and *m=1,…,4.*

Logit functions are computed by taking the log of the odds: logit(P) = log P/ (1-P). Although the relationship between logit and probit is almost indistinguishable: $Logit \approx (\pi/\sqrt{3}) \cdot Probit$; as defended by Finney (1947), the use of logit is preferred in the presence of extreme independent variable levels and with large data sets.

3.2. Measures

3.2.1. Dependent variable

In the present analysis, we are interested in the absorptive capacity enablers that can affect a service or manufacturing firm's generation of innovations. The outcome (response) variable used is Product Innovation (we have computed a new variable that captures whether the firm has created new product innovations and/or new service innovations), a binary variable corresponding to product/service innovation (*1* for a firm that has carried out product/service innovation and *0* otherwise). This variable excludes new products/services acquired from other firms or simple aesthetic improvements. The outcome variable is used as proxy to assess the innovation generation revealed by firms, as previously done by several authors such as Tether (2002), Quintana-Garcia and Benavides Velasco (2004) and Rusko (2011) according to the data available in the CIS survey. The predictor variables of interest are all binary too.

3.2.2. Independent variables

We have selected a set of independent variables that represent firms' absorptive capacity, namely: external acquisition of R&D, acquisition of other external knowledge, acquisition of equipment, software and licenses, these last three being related to external acquisition of knowledge and complementarity (Nelson and Winter 1982; March 1991; Lundvall and Johnson 1994; Van den Bosch et al. 1999; Johnson et al. 2002; Zahra and George 2002; Nerkar and Roberts 2004; Vinding 2004; Miller et al. 2007;

Rothaermel and Alexandre 2009; Heras 2014) whether or not the firm has graduate employees (Cohen and Levinthal 1989. 1990. 1994; Rothwell and Dodgson 1991; Mangematin and Nesta 1999; Narula 2004; Vinding 2000. 2004; Giuliani and Bell 2005) training in innovation-related areas carried out by firms (Nelson and Winter 1982; March 1991; Delaney and Huselid 1996; Koch and McGrath 1996; Nerkar and Roberts 2004; Miller et al. 2007; Heras 2014) the firm's internal R&D (Cohen and Levinthal 1989; Gambardella 1992; Cassiman and Veugelers 2006; Li 2011) cooperation with competing firms (Lundvall 1988; Jaffe 1989; Freeman 1991, 1994; Sako 1994; Shaw 1994; Brandenburger and Nalebuff 1996; Coombs et al. 1996; Dussauge et al. 2000; Cohen et al. 2002; Garraffo 2002; Tether 2002; Quintana-Garcia and Benavides-Velasco 2004; Rusko 2011) and cooperation with consultants universities and laboratories (Jaffe 1989; Cockburn and Henderson 1998; Cohen et al. 2002; Kostopoulos et al. 2011; Li 2011; Vasudeva and Anand 2011).

A brief description of the variables is presented below in Table 1, namely descriptive statistics and linear correlation coefficients.

3.2.3. Control variables

The NACE classification, i.e., disaggregation of activity sector (including sector codes available in the dataset) was used for controlling purposes. A dichotomous variable was computed and disaggregated between service and manufacturing firms. In addition, size was used as a control variable, since it is an instrumental variable commonly used in the empirical literature on entrepreneurship and small business management. For this purpose, the number of employees is grouped in three ranges, namely: [1; 49]; [50; 249]; and≥ 250.

4. Results

4.1 Descriptive statistics and multicollinearity analysis

Table 1 presents a set of descriptive statistics for the dataset consisting of 1133 firms, which is a large sample and a real asset in providing robustness to the estimators obtained. Approximately 50.4% of firms are service firms, and 49.6% are manufacturing firms. From observing Table 1, we retain that the average firm has from 0 to 49 employees. 81% of firms have generated product innovations, 59% carry out internal R&D and 60% usually acquire external R&D. 56% usually acquire other external knowledge and 21% other equipment, software and licenses. In addition, 21% said they organized training for employees in areas related to innovation and 68% have graduate employees. Regarding cooperation relationships, 28% cooperate with competing firms, 45% with consultants, 43% with universities and 54% with laboratories.

Table 2 shows that the VIF for the above-mentioned variables are mainly situated between 1 and 5, which indicates some linear correlation between the variables, although not enough to cause a multicollinearity problem.

[Insert Table 1 about here]

[Insert Table 2 about here]

4.2 Logit estimation results

We examine our hypotheses on the effect of external acquisition of R&D, acquisition of other external knowledge, acquisition of equipment, software and licenses, firms having graduate employees, training in innovation-related areas, the firm's internal R&D, cooperation with competing firms, cooperation with consultants, and cooperation with universities and laboratories on the generation of innovation. Our aim is to focus on whether this set of internal and liaison factors of absorptive capacity affect the firm's generation of innovation, and if this effect is different according to the firm being from the manufacturing or service sector. As product innovation generation is a dichotomous variable, we test our hypotheses using a logistic regression framework. Specifically, to test our hypotheses at the firm level, we estimate a regression run on the whole dataset and for service and manufacturing firm sub-samples separately, by considering the two sub-samples previously referred to: service firms and manufacturing firms; according to the NACE Eurostat classification.

To test Hypothesis *1a*, we examine the coefficient on external acquisition of R&D, for Hypothesis *1b* the acquisition of other external knowledge, for Hypothesis *1c* the acquisition of equipment, software and licenses, for Hypothesis *2* the firm having graduate employees, for Hypothesis *3* training in innovation-related areas, for Hypothesis *4* the firm's internal R&D, for Hypothesis *5* cooperation with competing firms, for Hypothesis *6a* cooperation with consultants, for Hypothesis *6b* cooperation with universities and for Hypothesis *6c* cooperation with laboratories.

From the results presented below in Table 3 for 'All firms' and considering product innovation as the dependent (response) variable, we can conclude that for the firms analysed, the likelihood ratio Chi-square of 89.053, with a p-value of 0.000, confirms that our model as a whole is statistically significant.

[Insert Table 3 about here]

For this sample, and regarding Hypothesis *1a* and *1b*, the independent variables explaining firms' innovation generation are the acquisition of external R&D activities and acquisition of other external knowledge, which have a positive and significant effect, thus supporting both hypotheses and being consistent with prior studies, such as those by Nelson and Winter (1982), March (1991), Lundvall and Johnson (1994), Van den Bosch et al. (1999), Johnson et al. (2002), Zahra and George (2002), Nerkar and Roberts (2004), Vinding (2004), Miller et al. (2007), Rothaermel and Alexandre (2009) and Heras (2014).

We find that firms' internal R&D is positively related to generation of innovation, having a positive and significant effect on the dependent variable, also supporting Hypothesis *4*. This is also consistent with previous studies (Cohen and Levinthal 1989; Gambardella 1992; Cassiman and Veugelers 2006; Li 2011).

In support of Hypothesis *5*, we find that cooperation relationships with competing firms also have a positive and significant effect on generating innovations, in line with prior research (Lundvall 1988; Jaffe 1989; Freeman 1991, 1994; Sako 1994; Shaw 1994; Brandenburger and Nalebuff 1996; Coombs et al. 1996; Dussauge et al. 2000; Cohen et al. 2002; Garraffo 2002; Tether 2002; Quintana-Garcia and Benavides-Velasco 2004; Vega-Jurado et al. 2008; Rusko 2011).

We also find support for Hypothesis *6a,* stating that firms' cooperation relationships with consultants affect their generation of innovation positively and significantly. This finding is consistent with the previous work of Jaffe (1989), Cockburn and Henderson (1998), Cohen et al. (2002), Kostopoulos et al. (2011), Li (2011) and Vasudeva and Anand (2011).

As for the control variables, we find significant evidence that sector of activity, specifically the fact of being a service firm, exerts a positive and significant effect on generation of innovation, the sector dummy variable being consistently positive and significant in explaining firms' generation of new products.

Having disaggregated the whole firm sample in two, manufacturing and services, and considering manufacturing firms (see Table 4 presented below), we obtain a likelihood ratio Chi-square of 27.69, with a p-value of 0.006, confirming that the model as a whole is statistically significant.

[Insert Table 4 about here]

The results now obtained allow us to ratify Hypothesis *1b*, predicting a positive and significant effect of the acquisition of other external knowledge on firms' generation of innovation. This finding is in line with previous results obtained by Nelson and Winter (1982), March (1991), Lundvall and Johnson (1994), Van den Bosch et al. (1999), Johnson et al. (2002), Zahra and George (2002), Nerkar and Roberts (2004), Vinding (2004), Miller et al. (2007), Rothaermel and Alexandre (2009) and Heras (2014).

We found no support for Hypotheses *1a* and *1c*, concerning external acquisition of R&D and acquisition of equipment, software and licenses.

In relation to Hypothesis *3*, for manufacturing firms, we found a negative and significant effect of innovation-related training on their generation of innovation. Thus we do not support Hypothesis *3* for manufacturing firms, these results contradicting previous studies.

Regarding Hypothesis *6a*, estimation results support the premise that cooperation relationships with competing firms present a positive and significant association with generating innovation (at 1% significance level), confirming previous analyses.

For the control variables, we do not find any evidence of a significant effect on product innovation.

When considering the set of results for the service firm sample (see Table 5 presented below), we can also conclude that for the firms analysed, the likelihood ratio Chi-square of 145.341 with a p-value of 0.000 confirms our model as a whole is statistically significant.

[Insert Table 5 about here]

Taking into consideration the results obtained, for the service firm sub-sample, the firm's generation of innovation is explained by external acquisition of R&D, thus revealing support for both Hypotheses *1a* and *1b*, in line with previous empirical findings, although at different significance levels, 5% and 10%, respectively.

For Hypothesis *4*, referring to the firm's internal R&D capacities, we verify a positive and significant effect (at 5% significance level) on its generation of innovation, supporting this hypothesis and the previous literature.

In assessing Hypotheses *6a* and *6b*, we found a positive and significant effect (at 1% significance level) of cooperation relationships with consultants and universities on the firm's generation of innovation, showing that service firms are more likely to establish links with R&D stakeholders than manufacturing firms.

Regarding our control variables, this sample shows a negative and significant effect of the NACE and the sector of activity dummy variable on the firm's generation of innovation, at 1% significance level. We also find a significant effect of firm size on its capacity to generate innovation, although positive in this case.

A brief summary is presented in Table 6, contrasting the literature review and the empirical findings obtained here.

[Insert Table 6 about here]

Taking as reference the conceptual model proposed in Section 2.3 (see Figure 1 above) to assess firms' generation of innovations and contrasting the results obtained for the sub-samples of manufacturing and service firms, four insightful implications for R&D managers on the determinant factors of a firm's capacity to create new products/services are provided, namely:

a) Firms' internal factors of absorptive capacity:

(i) For manufacturing firms, the acquisition of external R&D has a positive and significant association with generation of innovations; training in innovation areas has a negative and significant effect on the generation of innovation.

(ii) For service firms, acquisition of external R&D activities and internal R&D capacities show a positive and significant association with generating innovation.

b) Firms' liaison factors of absorptive capacity:

(iii) For manufacturing firms, establishing cooperation liaisons with other competing firms has a positive and significant effect on the generation of innovation;

(iv) For service firms, the cooperation links with consultants and universities have a positive and significant effect on the generation of innovation.

5. Conclusions

Prior research on absorptive capacity lacks analysis focused on its antecedents, namely the factors linked to the firm-level characteristics or the set of relations firms establish to absorb knowledge from important external sources, since it is mainly concerned with firms' R&D activities. Cohen and Levinthal (1990) opened up the trajectory on this topic for several researchers, with special mention for the work of Zahra and George (2002) and lately that of Vega-Jurado et al. (2008), but many insights are still lacking, for guiding practitioners, managers and science and public policy designers.

Our study takes the model of absorptive capacity (Zahra and George 2002) to another level of detail, proposing a complementary model of absorptive capacity, as it pays attention to a set of elements dealing with the assimilation of knowledge and complementarity and adds the liaisons firms establish in order to achieve knowledge spillovers.

A dataset of 1133 firms divided in two sub-samples of 562 manufacturing firms and 571 service firms is used to assess the effects of the variables related to the internal factors of firms' absorptive capacity and firms' liaison factors on the generation of innovation.

The conceptual model now proposed is innovative in the sense that it takes into consideration not only firms' R&D activities, but also firm-level characteristics, such as employees' education and training, and efforts to acquire external knowledge and complementarity. In addition, from an absorptive capacity perspective, firms must have an open innovation mind-set, establishing this through a series of liaisons to absorb useful external sources.

We found a caveat in the literature on absorptive capacity models, as previous studies do not approach the determinant factors of that capacity based on the links between firms and external sources of knowledge, isolating their effect. In addition, previous studies do not analyse manufacturing and service firms in a simultaneous analytical framework, which prevents contrasting the distinct effects now revealed.

The model proposed opens up Zahra and George (2002)'s model, inserting the firm into an open system, where in order to innovate it must establish an open innovation business model to be able to detect external knowledge, connect to external sources, absorb and exploit that knowledge in order to transform it into new products and services.

In detail, and concerning firms' internal factors of absorptive capacity, when looking at the sample as a whole, the major effect on the creation of new products and services comes from the firm's internal R&D capacities (according to previous research: Cohen and Levinthal 1989; Gambardella 1992; Cassiman and Veugelers 2006; Li 2011), as well as the acquisition of complementary knowledge, in the form of external R&D and other external knowledge (the last is also important for manufacturers), also in line with previous studies (Nelson and Winter 1982; March 1991; Lundvall and Johnson 1994; Van den Bosch et al. 1999; Johnson et al. 2002; Zahra and George 2002; Nerkar and Roberts 2004; Vinding 2004; Miller et al. 2007; Rothaermel and Alexandre 2009; Heras 2014).

One puzzling result compared to the previous literature is that in manufacturing firms' internal factors of absorptive capacity, employees' training in innovation appeared to have a negative effect on the creation of new products and services. This result does not support our hypothesis or the previous literature, which indicates training and skills as favouring innovation in firms (Nelson and Winter 1982; March 1991; Delaney and Huselid 1996; Koch and McGrath 1996; Nerkar and Roberts 2004; Miller et al. 2007; Heras 2014). Nevertheless, the result is justified by the use of a sample of Portuguese firms, which are part of an aging industrial structure not oriented towards attracting and incorporating external scientific knowledge. Moreover, Portuguese manufacturing firms still operate under a passive subcontracting logic, which has delayed positive developments in terms of increasing employees' qualifications.

Service firms' internal factors with most effect on innovation generation are related to their R&D activities, namely external acquisition of R&D and internal R&D capacities.

Analysing firms' liaison factors of absorptive capacity, our study confirmed the previous literature, by ratifying empirically the positive and significant effect of establishing liaison cooperation agreements with other firms, such as competing firms in the industry, on the generation of innovation. This conclusion is also validated for manufacturers. Thus, our findings support prior work (Lundvall 1988; Jaffe 1989; Freeman 1991, 1994; Sako 1994; Shaw 1994; Brandenburger and Nalebuff 1996; Coombs et al. 1996; Dussauge et al. 2000; Cohen et al. 2002; Garraffo 2002; Tether 2002; Quintana-Garcia and Benavides-Velasco 2004; Vega-Jurado et al. 2008; Rusko 2011).

For services, the most important liaison factors originate in consultants and universities. These results agree with the previous work of Vega-Jurado et al. (2008), who also conclude that firms that prefer links with industry partners have usually less capacity to acquire scientific knowledge and are more prone to acquire applicable knowledge, as a high level of internal knowledge is not required to absorb the external knowledge. On the contrary, firms with more liaisons with scientific partners are usually more focused on assimilating and decoding and thus exploiting scientific knowledge.

To sum up, firms must be able to detect, assimilate and exploit diverse sources of knowledge, but they must have tools enabling them to do so and become more innovative. Firms must detect external sources of knowledge, and must develop their own internal capacities and links with external stakeholders, to successfully incorporate the specific needs of their economic activity.

5.1. Implications for R&D managers and science and public policy makers

R&D managers must be aware of the set of determinants that drive the firm's absorptive capacity, so that they can prepare and tune them to fully exploit external knowledge and promote the firm's generation of innovation.

By understanding the driving forces of a firm's capacity to detect and assimilate knowledge spillovers from the environment, the factors related to firm-level internal capacities, for instance, internal R&D, acquisition of external R&D and other knowledge and materials, the skills and training of human resources, or the firm's liaison agreements with external sources of knowledge, managers will be able to design specific and customized open innovation business models.

In terms of policy implications arising from the present study, it is suggested that science and public policies should be directed towards consolidating firms' absorptive capacity and fostering cooperation dynamics among firms, competing firms and the scientific community, securing formal channels and mechanisms for developing joint innovation. Such mechanisms are already being introduced, for example, by the European Commission, to foster joint R&D efforts, with innovation vouchers or specific support schemes under Horizon 2020. Nevertheless, these must acknowledge what really lies underneath firms' enablers, either internal or arising from their liaison frameworks, so that such instruments are designed to address firms' needs.

By separating our sample into services and manufacturers we intended to reveal their innovative performance founded on specific internal determinants and cooperation dynamics. Thus, the present study provides a useful framework for dealing with firms' absorptive capacity, taking into account each sector's specificities.

In addition, our results can be helpful when drawing up guidelines to increase firms' capacity to assimilate innovativeness and foster open innovation workflows, in order to better assimilate what is really important for their needs in external knowledge sources.

Overall, the results obtained here may provide helpful starting points for practitioners (e.g. company managers) who wish to forecast the possible trajectory of their organization's R&D projects, through coopetition arrangements with partners, in order to improve the efficiency of technology transfer flows, and consequently stimulate the creation and diffusion of their innovations, but also to regulate their defensive mechanisms to be used as regimes of appropriability.

6. Limitations and further research

The main limitation of the present study is the lack of information on firms' innovative capacity when trying to access data connected with regimes of appropriability, specifically on patenting and licensing behaviour and other IP rights, such as copyrights and trademarks. This is also the main limitation of the database used in this study, the European CIS Survey, 2010, which shows the quasi-inexistence of data regarding firms' IP performance, considering additional data on patents, copyrights and other IP rights, since the only reference to innovative products or services internally generated by the firm that can be protected via formal IP mechanisms, is the one corresponding to the variable of product/service innovation.

In this connection, future research could explore the factors motivating firms to behave alternatively, in terms of R&D business models, based on customising their open innovation business model.

In addition, modelling firms' open innovation strategy and their absorptive capacity pathway can be enriched by analysing diverse liaison strategies to absorb external knowledge and establish technology transfer activities, such as cross-licensing, out-licensing or in-licensing strategies, and competitive/technological surveillance or forecasting projects.

Firms' generation of innovation, based on Intellectual Property strategies and the characteristics influencing their coopetition arrangements, should be further explored by examining the entrepreneurial profile of their founders, CEOs, management team, corporate governance, capital structure, public funding or venture capital presence. Despite the limitation of the data, it would be of interest to analyse other countries' profiles, contrasting them with the dataset used here.

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TABLES

Table 1. Descriptive statistics and linear correlation coefficients

Variable	Description	Obs.	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Product_innov (1)	Generation of new products and services, 1 if yes, 0 otherwise	1133	0.81	0.394	1.000													
External_ acquisition_ R&D (2)	Firm's external acquisition of R&D, 1 if yes, 0 otherwise	1133	0.60	0.49	0.146	1.000												
Acquisition other external knowledge (3)	Firm's external acquisition of other knowledge, 1 if yes, 0 otherwise	1133	0.56	0.497	0.160	0.370	1.000											
Acquisition equipment, software, licenses (4)	Firm's external acquisition of equipment, software, licenses, 1 if yes, 0 otherwise	1133	0.21	0.404	0.092	0.297	0.288	1.000										
Employees' graduated (5)	Employees with graduation studies, 1 if yes, 0 otherwise	1133	0.68	0.466	0.125	0.422	0.411	0.296	1.000									
Training in innovation (6)	Firm's training innovation for employees, 1 if yes, 0 otherwise	1133	0.21	0.408	0.087	0.141	0.180	0.170	0.204	1.000								
Internal R&D (7)	Firm's internal R&D, 1 if yes, 0 otherwise	1133	0.59	0.491	0.110	0.124	0.050	0.144	-0.050	0.101	1.000							
Cooperation_ competing firms (8)	Firm cooperate with competing firms, 1 if yes, 0 otherwise	1133	0.28	0.548	0.126	0.168	0.213	0.227	0.260	0.676	0.080	1.000						
Cooperation_ consultants (9)	Firm cooperate with consultants, 1 if yes, 0 otherwise	1133	0.45	0.622	0.158	0.133	0.180	0.161	0.182	0.140	0.147	0.305	1.000					

Cooperation_ universities (10)	Firm cooperate with universities, 1 if yes, 0 otherwise	1133	0.43	0.595	0.132	0.149	0.160	0.132	0.175	0.082	0.136	0.216	0.487	1.000			
Cooperation_ laboratories (11)	Firm cooperate with laboratories, 1 if yes, 0 otherwise	1133	0.54	0.535	-0.020	-0.222	-0.236	-0.106	-0.500	0.081	0.212	0.030	0.146	0.211	1.000		
Nace (12)	Disaggregation of activity sector	1133	50.2	21.624	-0.033	-0.240	-0.206	-0.090	-0.454	-0.001	0.118	-0.084	-0.123	-0.066	0.370	1.000		
Size (13)	1 – 10 to 49; 2 – 50 to 249; 3 - + 250	1133	1.74	0.798	0.075	0.142	0.077	0.084	0.172	-0.018	0.132	0.005	0.146	0.119	-0.023	0.059	1.000	
Sector (14)	Firm's sector of activity, 1 if services, 0 if manufacturing	1133	1.50	0.500	0.021	0.333	0.309	0.168	0.575	0.015	-0.127	0.152	0.162	0.114	-0.449	-0.767	0.089	1.000

Table 2: Multicollinearity analysis

Variable	Standardized Coefficients	Sig.	VIF
Nace	-0.07***	0.00	2.57
Size	0.04	0.14	1.13
Product_innov	0.07	0.23	1.14
External_acquisition_R&D	0.10**	0.03	1.35
Acquisition other external knowledge	0.00***	0.00	1.22
Acquisition equipment, software, licenses	-0.01	0.93	1.98
Employees' graduated	0.06	0.20	2.11
Training in innovation	0.06	0.76	2.21
Internal R&D	0.07**	0.03	1.38
Cooperation_competing firms	0.09	0.12	1.47
Cooperation_consultants	0.05**	0.01	1.45
Cooperation_universities	-0.04	0.16	1.77
Cooperation_laboratories	-0.16	0.34	3.15
Sector	-0.07***	0.00	2.57

***P ≤ .10; **P ≤ .05; ***P ≤ .01**

Table 3: Logit analysis: All firms – Response variable: Firm's generation of innovation

Prod_innov	**Coefficient**	**Std. Err.**	**z**	**P>z**
Nace	-0.009	0.006	0.991	0.118
Size	0.152	0.109	1.164	0.164
External_acquisition_R&D	**0.411****	**0.185**	**1.509**	**0.026**
Acquisition other external knowledge	**0.528*****	**0.182**	**1.695**	**0.004**
Acquisition equipment, software, licenses	0.013	0.245	1.013	0.959
Employees' graduated	0.322	0.253	1.379	0.203
Training in innovation	-0.304	0.322	0.738	0.345
Internal R&D	**0.353****	**0.166**	**1.423**	**0.034**
Cooperation_competing firms	**0.627****	**0.292**	**1.872**	**0.032**
Cooperation_consultants	**0.508*****	**0.184**	**1.662**	**0.006**
Cooperation_universities	0.259	0.181	1.296	0.152
Cooperation_laboratories	-0.239	0.227	0.788	0.293
Sector services	**1.039*****	**0.310**	**2.826**	**0.001**

N = 1133; Dependent variable: Product innovation.
***P ≤ .10; **P ≤ .05; ***P ≤ .01**

Table 4: Logit analysis: Manufacturing Firms – Response variable: Firm's generation of innovation

Prod_innov	**Coefficient**	**Std. Err.**	**z**	**P>z**
Nace	0.001	0.006	1.001	0.902
Size	-0.100	0.152	0.905	0.511
External_acquisition_R&D	0.029	0.270	1.030	0.914
Acquisition other external knowledge	**0.576****	**0.244**	**1.780**	**0.018**
Acquisition equipment, software, licenses	0.197	0.289	1.217	0.496
Employees' graduated	0.215	0.509	1.240	0.673
Training in innovation	**-2.081*****	**0.785**	**0.125**	**0.008**
Internal R&D	0.062	0.239	1.064	0.795
Cooperation_competing firms	**1.939*****	**0.715**	**6.948**	**0.007**
Cooperation_consultants	0.101	0.203	1.106	0.620
Cooperation_universities	-0.349	0.217	0.705	0.108
Cooperation_laboratories	0.174	0.281	1.190	0.536
Sector	0.001	0.006	1.001	0.902

N = 562; Dependent variable: Product innovation.
$*P \leq .10$; $**P \leq .05$; $***P \leq .01$

Table 5: Logit analysis: Service Firms – Response variable: Firm's generation of innovation

Prod_innov	**Coefficient**	**Std. Err.**	**z**	**P>z**
Nace	**-0.075*** **	**0.026**	**0.928**	**0.005**
Size	**0.392** **	**0.179**	**1.480**	**0.029**
External_acquisition_R&D	**0.707** **	**0.302**	**2.029**	**0.019**
Acquisition other external knowledge	**0.532* **	**0.319**	**1.702**	**0.096**
Acquisition equipment, software, licenses	-0.462	0.515	0.630	0.369
Employees' graduated	0.135	0.446	1.144	0.763
Training in innovation	0.269	0.560	1.308	0.631
Internal R&D	**0.602** **	**0.258**	**1.826**	**0.020**
Cooperation_competing firms	0.611	.0.590	1.842	0.301
Cooperation_consultants	**1.630*** **	**0.514**	**5.103**	**0.002**
Cooperation_universities	**1.557*** **	**0.474**	**4.747**	**0.001**
Cooperation_laboratories	0.022	0.478	1.023	0.963
Sector	**-0.075*** **	**0.026**	**0.928**	**0.005**

N = 571; Dependent variable: Product innovation.
***P ≤ .10; **P ≤ .05; ***P ≤ .01**

Table 6: Literature *vs.* Empirical Findings: Summary

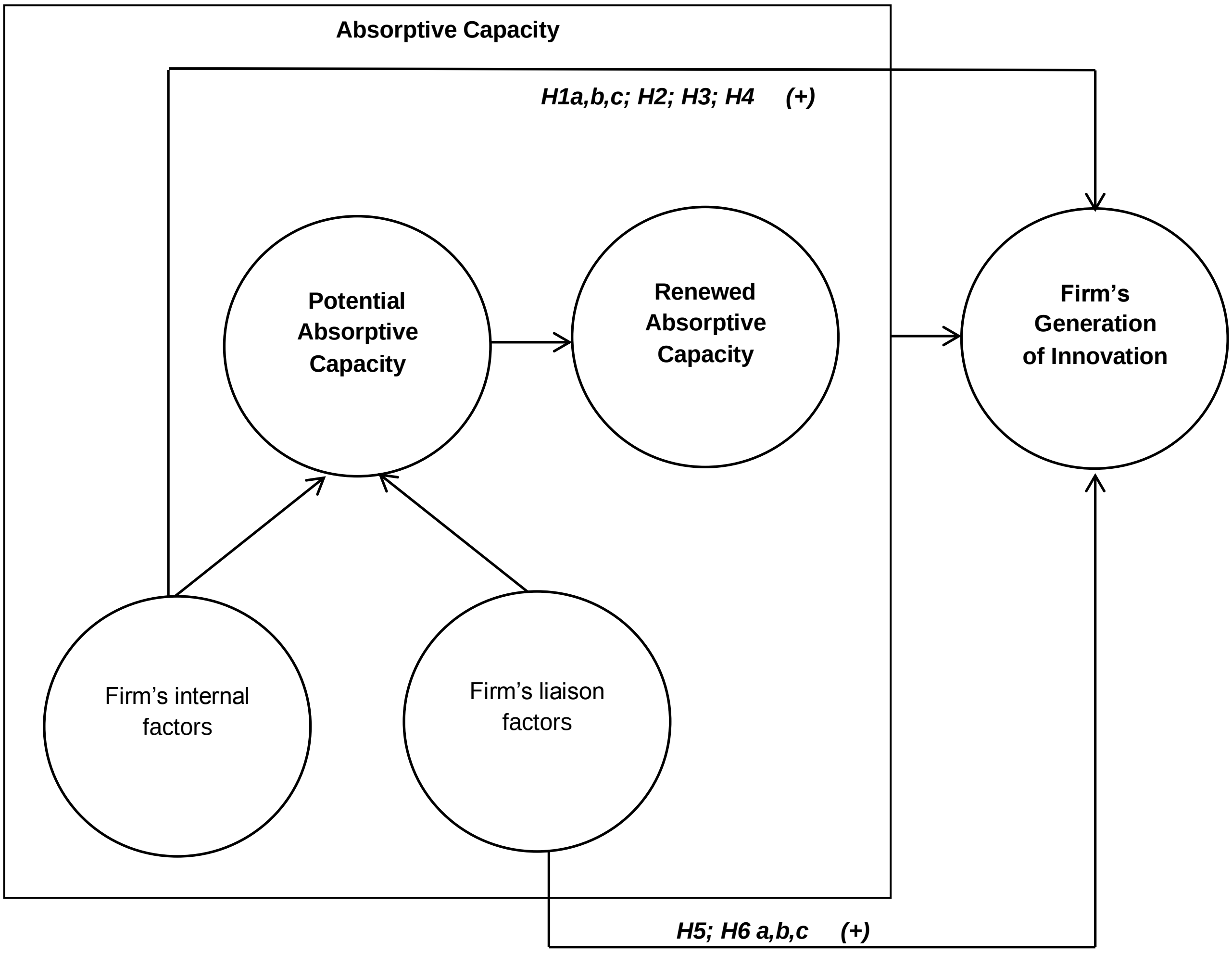
Literature	**Research hypothesis**	**Dependent variable: Firm's generation of innovation**			
		All firms		**Manufacturing firms**	**Service firms**
		ES	**SO**		
Nelson and Winter 1982; March 1991; Lundvall and Johnson 1994; Van den Bosch et al. 1999; Johnson et al. 2002; Zahra and George 2002; Nerkar and Roberts 2004; Vinding 2004; Miller et al. 2007; Rothaermel and Alexandre 2009; Heras 2014.	*H1a*	**(+)**	**0.411****	0.029	**0.707****
	H1b	**(+)**	**0.528*****	**0.576****	**0.532***
	H1c	**(+)**	0.013	0.197	-0.462
Cohen and Levinthal 1989, 1990, 1994; Rothwell and Dodgson 1991; Mangematin and Nesta 1999; Narula 2004; Vinding 2000, 2004; Giuliani and Bell 2005; Fosfuri and Tribó 2008; Vega-Jurado et al. 2008.	*H2*	**(+)**	0.322	0.215	0.135
Nelson and Winter 1982; March 1991; Delaney and Huselid 1996; Koch and McGrath 1996; Nerkar and Roberts 2004; Miller et al. 2007; Heras 2014.	*H3*	**(+)**	-0.304	**-2.081*****	0.269
Cohen & Levinthal 1989; Gambardella 1992; Cassiman and Veugelers 2006; Li 2011.	*H4*	**(+)**	**0.353****	0.062	**0.602****
Lundvall 1988; Jaffe 1989; Freeman 1991, 1994; Sako 1994; Shaw 1994; Brandenburger & Nalebuff 1996; Coombs et al. 1996; Dussauge et al. 2000; Cohen et al. 2002; Garraffo 2002; Tether 2002; Quintana-Garcia & Benavides-Velasco 2004; Vega-Jurado et al. 2008; Rusko 2011.	*H5*	**(+)**	**0.627****	**1.939*****	0.611

Jaffe 1989; Cockburn & Henderson 1998; Cohen et al. 2002; Kostopoulos et al. 2011; Li 2011; Vasudeva and Anand 2011.	*H6a*	**(+)**	**0.508*** **	0.101	**1.630*** **
	H6b	**(+)**	0.259	-0.349	**1.557*** **
	H6c	**(+)**	-0.239	0.174	0.022
Number of observations			1133	562	571
Wald			363.850***	187.846***	175.901***
Chi^2			89.053***	27.693***	145.341***

N = 1133; Dependent variable: Product innovation. ***P ≤ .10; **P ≤ .05; ***P ≤ .01**
Legend: ES (expected signals); SO (signals obtained).

FIGURE

Figure 1. Firms' Absorptive Capacity and Generation of Innovation: A Conceptual Model Proposal



Source: Adapted from Zahra and George (2002:192); Todorova and Durisin (2007).