DETERMINANTS OF INNOVATIVENESS IN SMES. DISENTANGLING CORE INNOVATION AND TECHNOLOGY ADOPTION CAPABILITIES

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Please quote a revised version of the paper

Martínez-Román J.A., & Romero, I., 2017. Determinants of innovativeness in SMEs: disentangling core innovation and technology adoption capabilities. Review of Managerial Science (forthcoming), DOI: 10.1007/s11846-016-0196-x

ABSTRACT

This paper studies innovativeness in SMEs from a set of innovation indicators at the firm level, capturing various types of innovation (product, process, organisational, and marketing innovations) and the level of innovativeness in these firm's developments. The article identifies two separate dimensions in the innovativeness of Spanish SMEs, using factor analysis techniques. One dimension is associated with the capabilities for core/internal innovation and the other with the capabilities for the adoption of technology. The paper shows that significant differences exist in the personal and organisational factors that favour these two dimensions. The entrepreneur's motivation, business planning, and cooperation in R&D activities constitute significant factors when considering the core dimension of a firm's innovativeness, but have no effect on the firm's capabilities for technology adoption. However, the use of external consultancy services seems to have no significant effect on the core dimension of the innovativeness of an SME, whereas it is a relevant factor for its technology adoption. Furthermore, it is shown that the entrepreneur's education plays a more significant role in the core dimension of a firm's innovativeness than in its capabilities for technology adoption. Depending on the policy objectives, these differences should lead to the application of specific policy approaches when an attempt to stimulate innovation in SMEs is made.

Keywords: Innovation; Innovativeness; SMEs; Entrepreneur; Spain

JEL: O31, R11, M21

1. INTRODUCTION

Innovativeness has been defined as the level of innovation incorporated (García and Calantone, 2002; Göktan & Miles, 2011) or the ability to bring radical innovations to the market (Eggers et al., 2014) in

technologies, processes, or products (Nelson and Winter, 1982). The radical nature of innovations reveals the creation of disruptive knowledge, which is considered the essence of innovation in the literature (Schumpeter, 1934; Nonaka and Takeuchi, 1995). In consequence, the degree of innovation of the firm's developments is a key issue when studying innovativeness (Bouncken et al., 2015). In this respect, the Oslo Manual (OECD, 2005) differentiates between worldwide, market, and firm-only innovation. This last category is associated with innovation or technology adoption or absorption, while the other two types represent more pure forms of innovation activity. The literature focuses on worldwide and market innovations but firm-only innovations should not be underestimated, particularly in the case of SMEs. This type of innovation can bring SMEs closer to the efficient technical frontier and favour their survival and economic success. In addition, the adoption of technology generated outside the firm can be accompanied by substantial modifications and adaptations that actually involve market innovations. Therefore, in spite of the clear theoretical delimitation proposed in the Oslo Manual, in practice it is often difficult to differentiate between firm-only innovations, which represent mere technology adoption, and market innovations. Thus, the introduction of a radical innovation (Christensen et al., 2015) and the use of new technologies (Johnson et al., 2008) usually require the renewal of the business model (Zott and Amit, 2010). In this sense, firms' innovativeness is directly associated with business model innovation, which allows companies to capture value in the market (Chesbrough, 2010; Teece, 2010).

From a different perspective, as proposed in the third edition of the Oslo Manual (OECD, 2005), four types of innovation can also be distinguished: product innovation, process innovation, marketing innovation, and organisational innovation. Certain authors refer to organisational innovation as developments in the allocation of responsibilities and hierarchical organization of the company, while the developments in operations, procedures and information flows are classified as managerial innovation (Kraus et al., 2012a). Empirical research frequently focuses on innovations in products and processes, while organisational and marketing innovations remain neglected or are even relegated (Camisón and Villar-López, 2011; Drejer, 2004; Trigo, 2013). Moreover, since innovation is complex in nature (Freeman et al., 1982; Kline, 1985), certain innovations can be classified into more than one category and interactions exist between these four types of innovations (OECD, 2005). Thus, organisational innovation can be autonomous, it can promote learning and communication in the business, it can be a factor supporting innovation in products and processes, or it can be a necessary response to technological change (Camisón and Villar-López, 2014; Damanpour et al., 1989; Mothe et al., 2015). Furthermore,

developments in markets influence the rest of the innovations and the interrelationships between innovations in products and processes are also highly relevant (Kraft, 1990; Laforet, 2008).

Nevertheless, the studies on innovation in SMEs generally focus on specific types of innovation based on the previous classifications. The literature following this approach shows that the factors explaining innovation vary across different categories of innovation (Bouncken et al., 2015; Ganter and Hecker, 2013; Romero and Martínez-Román, 2012; Varis and Littunen, 2010). Yet, as previously mentioned the frontiers between these types turn out to be diffuse when moving from theory to actual business practice. This paper seeks to contribute to this literature by proposing a different approach that allows:

(i) the capture of the overall complexity of innovation activities regarding both their functional content and their level of innovativeness, and also

(ii) empirical delimitation, which is based on data and not on theory, of two main dimensions in the innovativeness of an SME: the core innovation capabilities, and the capabilities for technology adoption.

Therefore, in this work, the SME's innovativeness is conceived as a latent, non-observable, characteristic of the firm that can be captured by means of considering certain observable innovation outcomes. The empirical analysis employs data from a survey of more than 1,500 Spanish SMEs and is based on a set of innovation indicators at the firm level, thereby capturing various types of innovation and the level of innovativeness in the firm's developments. The two latent dimensions shaping the SME's innovativeness (the capabilities for core/internal innovation and the capabilities for technology adoption) are identified from these indicators by using main component analysis techniques. Each of these dimensions incorporates the interactions between the different types and levels of innovations. From this perspective, these capabilities capture the complex nature of innovation in SMEs better than other, more simplistic innovation indicators.

The paper also studies the factors that explain these latent dimensions. In this respect, the results contribute to the literature by showing that a number of significant differences exist in the personal and organisational factors that promote these two dimensions in SMEs' innovativeness. From a policy perspective, these differences have straightforward implications. In this respect, the paper shows that policy makers should implement specific approaches depending on whether they are interested in fostering either technology adoption or purer forms of innovation.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1. The latent dimensions of a firm's innovativeness

The dynamic and multidimensional nature of innovation carries two conflicting implications for empirical research (Freeman et al., 1982; Schumpeter, 1934). On the one hand, it requires the identification and connection of various modalities to devise a classification and hierarchy of innovations. On the other hand, it shows the need to maintain a global and integral vision of the phenomenon, which reveals the common underlying foundation between the different types of innovation. This second line of work, which has seldom been explored in the literature, is an interesting channel that burrows deeper into the complex nature of the innovation phenomenon. This integrating approach looks into the common elements of the various expressions of innovation, thereby seeking an empirical description of the global dimension of innovation and its implications for management and policies in specific contexts.

The complex and multidimensional character of innovation is reflected in the inter-relationships that exist between technological innovations (product innovation and process innovation), and those innovations coming from the administrative system (organisational innovation and marketing innovation) (Armbruster et al., 2008; Damanpour et al., 1989; Varis and Littunen, 2010). These inter-relationships are obvious when observing how firms find a balance in practising the different types of innovation in accordance with their needs (Weerawardena, 2003). Thus, innovative performance is really a construct made up of the different forms of innovation carried out by the firm (Hagedoorn and Cloodt, 2003).

Nevertheless, in spite of the relevance of non-technological innovations in all sectors (Drejer, 2004) and their differences with respect to technological innovations (Chen, 2006), the traditional aim of research has been to disclose the foundation of technological innovation in firms (O´Cass and Weerawardena, 2009). The majority of studies have hence focused their attention on product innovations and process innovations. Non-technological innovations have generally passed unnoticed in empirical research (Damanpour and Aravind, 2012).

In order to achieve an ample conceptualisation of innovation, it is necessary to consider the technological and non-technological novelties and improvements that firms develop. Currently, organisational and marketing innovations are integrated into standardised assessment systems of innovative results at the institutional and firm level (Caird et al., 2013). However, the knowledge accumulated concerning these two types of innovation remains limited (Armbruster et al., 2008; Camisón and Villar-López, 2011).

In social sciences, the application of composite indicators for the synthetic summarisation of complex phenomena has become highly relevant in recent years (Cerulli and Filippetti, 2012). The literature has indicated the need to define innovation, by integrating its different modalities from a global perspective of the phenomenon (Damanpour, 1991; Porter, 1990), given the complementarity and inter-relationship between these modalities at the firm level (OECD, 2005). There has therefore been empirical verification of the additionality of the effects of marketing and organisational innovations in areas such as: the creation of sustained competitive advantage (Camisón and Villar-López, 2011); the interrelation between product and marketing innovations (Lee et al., 2011); and the especial contribution of organisational and managerial innovations to the business model innovation (Kraus et al., 2012a). The evidence of these and other associations between different types of innovation has led to multidimensional constructs being created by a series of authors. These authors, either partially (Lee et al., 2011) or totally (Wonglimpiyarat, 2010), group different ways of innovating into a unitary concept or a latent factor, which, using various procedures, is representative of firms' global innovations.

These constructs have been drawn up to offer a general vision of the relationships that exist between innovations and improvements incorporated into the products, processes, organisation, management, and business systems of firms. The challenge of this type of analysis consists of reconciling the integrated perspective of the research with the multidimensional nature of the innovative phenomenon of the firm. Thus, the complex and multidimensional structure of innovation has been evaluated using the Principal Components Analysis (PCA) technique (Gatignon et al., 2002). Empirical research has also used Confirmatory Factor Analysis (CFA) to form innovation constructs from a series of technological and non-technological innovations of a set of firms (Lee et al., 2011; O´Cass and Weerawardena, 2009). Nonetheless, other authors have preferred to represent this multidimensional character by constructing a global innovation index that uses the simple arithmetic mean (Wonglimpiyarat, 2010) or uses the weighted mean of the different types of innovation. In this latter case, the weight of the variables is assigned either according to the researcher's criterion (Martínez-Román et al., 2011) or to the opinion of an expert panel (Nystrom et al., 2002).

However, in these studies, the methodological approach and the research objectives lead to the identification of various latent dimensions in a firm's innovativeness, but only a synthetic measure of innovation is obtained. The only exception is Gatignon et al. (2002). In this instance the authors use a variety of scales to measure a set of theoretical constructs (competence enhancing versus competence

destroying, new competence acquisition, generational consolidation, and so forth) and then use these constructs as explanatory variables of commercial success and of the timing for the introduction of the innovations. This also represents a very different approach than that proposed in the current paper, which aims to identify the latent dimensions of a firm's innovativeness to later explore the explanatory factors that condition these dimensions.

Empirical research has identified two dimensions of innovative capacity associated with, respectively, the capabilities for internal knowledge creation and the capabilities for the external adoption of technologies for innovation (Bessant et al., 2012; Carlo et al., 2012; Mahroum and Al-Saleh, 2013). Similarly, other authors distinguish between new technology development and innovation in products and processes, thereby showing the existence of a duality in innovation (Tang and Murphy, 2012). Thus, innovation through technology adoption (incorporated or unincorporated) appears in some literature as an alternative way to achieve innovation (Hervás-Oliver et al., 2014) in an efficient manner (Mahroum and Al-Saleh, 2013). This path to innovation differs from the classic Schumpeterian itinerary, which is marked mainly by the generation of core innovation capabilities within the company. Indeed, innovation depends on both the adoption of new technology (Gil et al., 2012) and the intensity of internal R&D in companies (Gómez and Vargas, 2009). However, these two dimensions of innovation present differences in organisational routines that determine different innovation patterns (Hervás-Oliver et al., 2014). These differences have been insufficiently studied in the literature, despite the importance that they may have for the policy and management of innovation in SMEs.

The above considerations lead to the formulation of the following hypothesis:

H1: The core innovation capabilities and the capabilities for technology adoption represent two different latent dimensions of the SME's innovativeness.

2.2. Main determinants of innovativeness in SMEs

A review of the literature allows the identification of two main categories of explanatory factors for the two dimensions of SMEs' innovativeness: the personal characteristics of the entrepreneur, and the characteristics of the organisation.

2.2.1. The entrepreneur's personal characteristics

The personal conditions of the owner and the main person in charge of decision making are determinants in the innovative behaviour of SMEs, especially in the initial phases of the business. The entrepreneurs'

level of studies is one of the personal characteristics which tend to appear in the literature linked to innovative success (Koellinger, 2008; Marvel and Lumpkin, 2007) and economic performances in small firms (Kangasharju and Pekkala, 2002; Robinson and Sexton, 1994). At times, however, it turns out not to be so evident (Keizer et al., 2002). On certain occasions, the indirect influence of education through other personal features of the entrepreneur has been noticed, for example, by way of motivation and management style (Romero and Martínez-Román, 2012). A higher level of studies tends to be associated with a greater degree of cognitive complexity (Thompson et al., 2010). This will promote creativity (Nonaka and Takeuchi, 1995; Galende and De la Fuente, 2003), the discovery of business opportunities (Clarysse et al., 2011), and the entrepreneur's capacity for technological absorption (Hoffman et al., 1998). This is why it seems reasonable to consider the entrepreneur's educational level as being among the most influential characteristics in the innovative behaviour of small-sized firms.

The entrepreneur's motivation also plays an important role in the SMEs' innovative activity. The decision to become an entrepreneur can be a response to various motives (BarNir, 2012). There are people who become entrepreneurs to satisfy their goal-seeking drive or their professional aspirations (intrinsic motivations) while in other cases it is the wish for economic reward, or other motives of a material nature, which spurs them to make this decision (extrinsic motivations) (Cooper and Jayatilaka, 2006). There is mutual reinforcement between the two motivations (Amabile, 1998). According to the literature, entrepreneurs with extrinsic motivations are less prone to innovation than those who are moved by intrinsic motivations (Guzmán and Santos, 2001). There are also entrepreneurs who start their professional career as a solution to unemployment or due to professional dissatisfaction: necessity. In others, the initiative comes from a favourable set of circumstances in the market: opportunity (Reynolds et al., 2002). There is evidence that indicates that opportunity entrepreneurs have a longer professional career (Block and Sandner, 2009), while necessity entrepreneurs are more dissatisfied with their work even if they obtain benefits (Cotterill, 2012).

Other psychological features of entrepreneurs that also influence innovative behaviour in firms include: leadership capacity (Vowles et al., 2011); and risk-taking (Baron and Tang, 2011). Firm innovation can be prompted by the entrepreneur's ambition to grow and to take risks. In SMEs, firm growth seems to be closely linked to the owner's capacities, ambitions and skills (Morrison et al., 2003). The ambition of the founding entrepreneur for growth turns out to be decisive in the development of new low-tech firms (Stam and Wennberg, 2009). Nonetheless, a disproportionate ambition in comparison to

the entrepreneur's resources can lead to the closure of the firm (Littunen, 2000). Likewise, the growth of the business also appears to be related to strong leadership, high commitment, and a marked orientation towards technological change, among other factors (Gundry and Welsch, 2001).

Moreover, the entrepreneur's personal characteristics substantially influence the adoption of technology in organisations (Lin, 2014; Staw, 1991). Thus, the educational level of the entrepreneur and of the senior management is a particularly influential factor in the adoption of new technology (Autry et al., 2010; Correa et al., 2010), even in less technology-intensive industries (Romero and Martínez-Román, 2015). Other research has highlighted the importance of the entrepreneurs' professional experience (Tang and Murphy, 2012) and their management style (Venkatesh and Bala, 2008) in technology adoption, noting that support by the top management is crucial in overcoming barriers against change and the incorporation of new technology (Ragu-Nathan et al., 2004). In fact, a change in the management of the firm has been observed as having a decisive influence on the adoption of technology in the company (Barden, 2012).

Technology adoption is also clearly influenced by the entrepreneur's motivations and aspirations. Thus, growth-motivation owners tend to favour new technology adoption (Talebi and Tajeddin, 2011), collaboration in business networks, and a more communicative and participatory leadership style (Gray, 2004) in SMEs. Top managers' risk-taking also facilitates the adoption of innovations in enterprises (Harms et al., 2010).

Consequently, the previous literature has shown that the entrepreneur's personal characteristics have an impact on the two dimensions of SMEs' innovativeness. However, the core innovation capabilities and the capabilities for technology adoption are of a different nature and imply alternative organisational routines. Consequently, this paper postulates the following hypothesis in this respect:

H2: Significant differences exist in the influences that the entrepreneur's personal characteristics exert on the core innovation capabilities and the capabilities for technology adoption in SMEs.

2.2.2. Organisational characteristics of the firm

Organisational characteristics are shown to bear major influence on a firm's innovative activity. In this sense, the firm's size is a common factor in research as it represents the resources and capacities necessary for innovation (Caloghirou et al., 2004; Galende and De la Fuente, 2003). This is why the growth of the workforce is considered to be a source of internal knowledge in organisations (Hurley and

Hult, 1998; Nonaka and Takeuchi, 1995). The dimension of the workforce is also a relevant factor for the introduction of innovative products (Amara et al., 2008; Ganter and Hecker, 2013) and for the development of incremental improvements in the production processes (Bhaskaran, 2006). Notwithstanding, empirical research has not achieved decisive results concerning the influence of size on innovation. While some authors uphold that a greater size favours innovation (Arundel and Kabla, 1998), others highlight the natural inclination of small firms towards innovation (Acs and Audretsch, 1988; Laforet, 2008). Certain research has observed that the potential benefits of size are counteracted by the bureaucracy, complexity, and inertia that are generated beyond a certain organisational dimension (Chandy and Tellis, 2000; Dougherty and Hardy, 1996). This has led to certain studies that consider there to be a non-linear relationship between size and the level of innovation (Martínez-Román et al., 2011; Romero and Martínez-Román, 2012).

The literature shows the influence of a series of organisational characteristics on the generation of knowledge and innovation in firms. Several of these factors affect the firm's internal area and other factors affect the external knowledge sources. The internal factors highlight the specific character of innovation. This is based on the principle of limited rationality in decision making, on the importance of strategic planning, and on the influence of the structure and organisational routines on the generation of innovations (Nelson and Winter, 1982). The internal origin of knowledge creation lies in the effort in R&D activities (Forsman, 2011; Keizer et al., 2002) and in continuous learning while performing tasks (Caloghirou et al., 2004; Jiménez-Jiménez and Sanz-Valle, 2011). This explains why it is important to count on a programme of continuous staff training which fosters learning and individual creativity (Damanpour, 1991; Nonaka and Takeuchi, 1995) and facilitates knowledge transmission and innovation in the organisation (Freel, 2005; Hull and Covin de 2010). The activities related to business planning and risk management also drive the innovative activity of small firms and improve their results (Kapsali, 2008; Salomo et al., 2007). In this sense, much research views risk tolerance as an essential feature of the organisational culture of innovative firms (Hurley and Hult, 1998). This favours the innovative level in organisations (Forsman, 2011; Marcati et al., 2008), but, according to Kraus et al. (2012b: 161), those "innovative SMEs should minimize the level of risk". Likewise, formal planning is a practice that facilitates decision making in situations of risk and, moreover, has a positive effect on innovation in small firms (Romero and Martínez-Román, 2012).

It is also clear that internal organisational factors have a special influence on technology adoption in enterprises (Khanagha et al., 2013; Patterson et al., 2003; Romero and Martínez-Román, 2015). Thus, the firm size usually facilitates the incorporation of new technologies (Autry et al., 2010; Correa et al., 2010; Gómez and Vargas, 2009). In addition, internal R&D efforts (Correa et al., 2010) and learning routines increase the absorption capacity (Gil et al., 2012) and the ability to identify, assimilate and exploit external information for innovation (Cohen and Levinthal, 1990), thereby favouring the adoption of new technologies (Chaudhuri, 2012) and business performances (Kohtamäki et al., 2012). Furthermore, the implementation of planning systems in organisations favours technology adoption because a planning system enables risks to be controlled and reduces uncertainty in the organisation (Gil et al., 2012; Patterson et al., 2003).

However, although organisational characteristics influence the two dimensions of SMEs' innovativeness, they may do so in a different manner, as proposed in the hypothesis:

H3: Significant differences exist in the influences that internal organisational factors exert on the core innovation capabilities and on the capabilities for technology adoption in SMEs.

On the other hand, an ample part of the literature has analysed the influence of inter-firm cooperation on innovative activity in firms (Rondé and Hussler, 2005; Tödtling et al., 2009), especially in SMEs (Kaufmann and Tödtling, 2002; Konsti-Laakso et al., 2012). Indeed, external support has been shown to be highly significant in introducing knowledge and new technologies in SMEs (Narula, 2004). This is particularly true in traditional sectors and mature industries (Bhaskaran, 2006). Nevertheless, other research has verified that collaborating with other firms is not relevant in the introduction of radical innovations (Radas and Bozic, 2009). There are two aspects of cooperation for firms. Firstly, there is collaboration with other agents of the value chain, such as clients, suppliers, distributors and competitors (Ar and Baki, 2011; Freel, 2003). Secondly, there is R&D cooperation with agents of scientific and technical knowledge in their environment, such as universities and technological centres (Cowan and Zinovyeva, 2013), consultants and knowledge-intensive business services (KIBS) (Yam et al., 2011). The significance of both types of cooperation as sources of innovation has been confirmed through empirical research. Nonetheless, results show that small firms collaborate very little with universities and technological centres (Dyer and Singh, 1998). This reduces their level of innovation (Kaufmann and Tödtling, 2002). It has also been proved that collaboration with clients and suppliers benefits innovation in these firms (Ar and Baki, 2011). Cooperation in the value chain is associated with the incorporation of

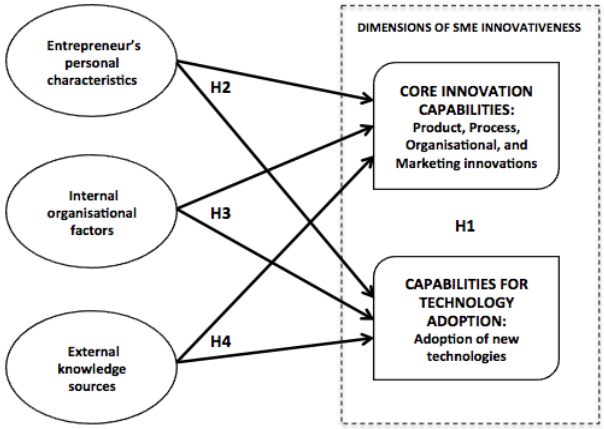
incremental improvements in SMEs. It is also related to the search for a competitive advantage based on the differentiation of the goods and services and on adaption to the customers' needs (Porter, 1990). Nevertheless, an excessive dependence on the value chains can lead to a restriction for the innovative activity of small firms (Romero, 2009).

The firm's contact with external knowledge sources has also been shown to have a major influence on firms' innovative behaviour. An example of this contact arises when technical staff attend congresses and business fairs related to the firm's activity (Jiménez-Jiménez and Sanz-Valle, 2011; Martínez-Román et al., 2015). Other authors have investigated the interrelations between the internal and external sources of innovation in the creation of technological knowledge in firms. In these studies it has been noted how external knowledge sources provide a stimulus for the development of R&D activities in the firm. In the same way, the R&D effort facilitates the capacity to detect, assimilate and exploit the market's technological opportunities (Nieto and Quevedo, 2005). Moreover, there is evidence of the impact that external factors, such as shared learning in formal networks (Bessant et al., 2012) and cooperation in the value chain (Patterson et al., 2003), have on the adoption of technologies. For example, the organisation may be driven to adopt new technologies in order to meet customer needs (Gil et al., 2012; Patterson et al., 2003). There is also evidence in the literature concerning the significant impact exerted by competition (Gil et al., 2012) from firms in the same sector on the decision to adopt new technologies.

Nevertheless, the different nature of the two latent dimensions in SMEs' innovativeness leads us to postulate the following hypothesis concerning the influence of external knowledge sources:

H4: Significant differences exist in the influences that external knowledge sources exert on the core innovation capabilities and the capabilities for technology adoption in SMEs.

Figure 1: Theoretical framework



3. METHODOLOGY

In this section, the dataset and the methodology used for the empirical analysis will be presented.

3.1. Data collection

Data for this study comes from a survey conducted in the last quarter of 2010 on SMEs in Spain. According to the European Commission's standards, SMEs were defined as businesses of up to 250 employees, and self-employed people without employees were not included in the survey. The survey was addressed to the person in the role of entrepreneur. In this respect, an operational definition of entrepreneur was adopted. This implies identifying the entrepreneur as any business owner (or co-owner) who also carries out managerial functions within the firm.

Ten pilot interviews were performed before starting the fieldwork in order to test the questionnaire and detect possible mistakes. This pilot study provided useful guidance towards improving the wording of the questions in order to make them clearer, facilitate the answers, and avoid misinterpretations. A response rate of 20.8 percent was obtained in the fieldwork, which was specifically carried out in six Spanish regions: Andalusia, Murcia, Extremadura, the Basque Country, Madrid, and Navarre. These regions were selected in an effort to provide a broad picture of the whole national economy. Thus, the first three regions are ranked among those regions with the lowest per capita income in Spain while the last three are the three richest regions in the country. The SMEs participating in the survey were randomly selected using public information from the Official Spanish Company Register. The stratified sample, with quotas for size groups and sectors, was representative of the business population of every region included in the study with an error of ±6.0% at a confidence level of 95.5 percent. The final dataset is made up of 1,583 observations. No bias was detected between respondents and non-respondents.

The questionnaire used in this research included queries on the innovative activities of the businesses and on different possible explanatory variables for these activities, by considering the personal characteristics of the business owner/manager and the characteristics of the firm's management.

The methodology adopted in this work consists of two steps. The first step is the measurement of innovativeness and the determination of its latent dimensions. For this exercise, factor analysis techniques

are used. The second step includes the study of the determinants of innovativeness in SMEs. The linear regression method is used for this purpose.

3.2. Identifying the latent dimensions of innovativeness

In order to approach innovativeness in SMEs, the business owners/managers who participated in the survey were asked whether in the previous three years they had carried out eight different types of innovation activities and, if so, they were asked to assess the level of innovativeness of these developments using a 7-item Likert scale (higher values of this variable indicate a higher degree of innovativeness). The eight types of innovation activities were the following:

- Introduction of new products.
- Acquisition of new machinery and equipment
- Acquisition of new software.
- Changes in the intermediate inputs acquired.
- Introduction of new production processes.
- Introduction into new markets.
- Changes in internal organization.
- Changes in the company's image or product presentation.

The answers were coded as eight variables, each one taking values from 0 to 7. Value 0 was assigned to those SMEs that had carried out no innovation activities, and value 7 to those SMEs that had introduced the most ambitious developments in each area. Table 1 shows the percentage of businesses that carried out each of these innovation-related activities and the mean value obtained for the overall measurement of the level of innovativeness in these developments. As can be observed, the highest values are obtained for the introduction of new machinery or equipment and new software; the lowest are obtained for accessing new markets and for the changes in the intermediate inputs employed in the companies' production processes.

Table 1. Descriptive indicators for the innovative activities

Type of activity	% (yes)	Mean	Type of activity	% (yes)	Mean
New products	49.75	2.49	New production processes	25.38	1.26
New machinery/equipment	76.13	3.98	New markets	23.93	1.16
New software	53.02	2.76	Changes in internal organisation	29.16	1.45
Changes in the intermediate inputs	24.69	1.16	Changes in the company's image or product presentation	42.00	2.22

As can be observed in the correlation matrix presented in the annex at the end of the paper, a significant correlation exists between these innovation variables. Hence, factor analysis techniques were used to capture the possible latent dimensions associated with the innovation variables. The principal component method was used applying an oblimin rotation in order to allow for a certain correlation between the components obtained in the analysis. As the result of this analysis, two principal components were obtained, as is shown in Section 4.1. below.

3.3. Studying the determinants of innovativeness in SMEs

In a second step, this paper studies the determinants of innovativeness in SMEs. To this end, the factors obtained in the principal component analysis of the innovation variables are used as dependent variables in a linear regression analysis. For this exercise, the following explanatory variables are included in this study:

A. Control variables:

- Number of employees (emp): firm size, measured by the number of employees, is included in the analysis as a continuous variable.

- The squared number of employees (emp2): This variable is intended to capture the possible non-linear relationship between firm size and innovation.

- Two sectorial dummies were also considered for the manufacturing industry (ind) and for services (serv).

B. Personal characteristics:

- Education (edu): this variable takes the value 1 for the business owners/managers without any formal studies; 2 for those with primary education; 3 for those with secondary education; 4 for those with higher professional training; and 5 for those with a university degree.

- Intrinsic entrepreneurial motivation (int_mot). The entrepreneurs interviewed were asked about their level of agreement with the following statement: "I became an entrepreneur because this was the best option for my personal and professional development".[1] The answers were coded in each case as ordinal variables which take values from 1 to 7 (7 meaning full agreement and 1 complete disagreement).

- Ambition for growth (ambition): The entrepreneurs interviewed were asked about their level of agreement with the following statement: "The idea that my business grows is very attractive to me". The answers were coded using a 7-item Likert scale.

- Risk-taking (risk): The entrepreneurs interviewed were asked about their level of agreement with the following statement: "In general, a tendency to undertake high-risk projects exists in my business". The answers were coded using a 7-item Likert scale.

C. Business characteristics:

Three variables were also included to identify the SMEs' internal capacity to introduce innovations:

- Innovation expenditure (inn_exp). The possible existence of a deliberate business policy oriented towards innovation is detected by using this dummy variable. This takes value 1 for those small businesses that have made some expenditure in innovation-oriented activities in the previous three years and 0 in the negative case.

- Training activities for workers (train). The managers/entrepreneurs were asked whether they regularly carried out training activities in their businesses in order to improve the capabilities of their workers and develop new skills. The answers were coded using a binary variable.

- Formal business planning of the various management areas (finance, marketing, logistics, human resources, etc.) (plan). This dummy variable takes the value 1 for the SMEs which undertook formal business planning on a regular basis, and 0 in the negative case. Those companies that undertake a rational and professional planning of their activities are more capable of managing complex innovation projects.

Four variables were also considered in order to capture the access of external information and knowledge that can favour innovation activities in SMEs.

[1] Other types of motivation were also considered in the survey, but are omitted from the analysis since they produced no significant results.

- R&D cooperation (r&d_coo). The managers/entrepreneurs interviewed were asked to assess the intensity of the R&D cooperation activities (if any) between their firms and universities or other technological centres, using a 4-item scale (from no cooperation to intense cooperation).

- Participation in trade fairs and conferences related to their business (fair). The managers/entrepreneurs interviewed were asked whether their company regularly participated in trade fairs, conferences or related activities regarding their business activity. The answers were coded using a binary variable.

- Suggestions or petitions from clients (client). The managers/entrepreneurs interviewed were asked whether the suggestions or petitions from their clients were used in their businesses as sources to increase their knowledge or information and improve their activity. The answers were coded using a binary variable.[2]

- Business consulting services (consult). The managers/entrepreneurs interviewed were asked whether they had hired business consulting services as a way of accessing specialised knowledge and of improving their activity. The answers were coded using a binary variable.

Table 2. Descriptive indicators for the independent variables

Control variables		*Business characteristics*	
Number of workers (mean)	7.66	Innovation expenditure (% yes)	29.79
Businesses in industry (%)	10.77	Training activities for workers (% yes)	71.16
Businesses in service sector (%)	47.42	Planning (% yes)	44.08
Personal characteristics		R&D cooperation (mean)	1.22
Educational level (mean)	3.97	Participation in trade fairs (% yes)	70.78
Intrinsic motivation (mean)	5.53	Suggestions or petitions from clients	50.25
Growth Ambition (mean)	5.35	(% yes)	
Risk-taking attitude (mean)	3.17	Business consulting services (% yes)	30.06

The descriptive indicators for the independent variables in the analysis are presented in Table 2. As can be observed, the average manager/business owner in the survey has secondary studies or higher professional training. The average business in the sample has 7 employees, operates in the services sector, does not regularly undertake business planning, and is not involved in cooperation activities with R&D institutions or universities.

[2] The survey also included questions regarding the role of competitors and suppliers as sources for innovation, in addition to the collaboration with clients. The possible influence of these variables was tested, but the coefficients turned out to be non-significant. Hence, these variables were removed from the final results presented herein.

4. RESULTS

The main results in each the two steps explained in the methodology section are now presented.

4.1. Results of the principal component analysis

As a result of applying the principal component method to the eight innovation variables, two factors are acquired that account for 49.19 percent of the total variance.[3] Table 3 presents the structure matrix containing the variable-factor correlations.

Table 3. Structure matrix

	Factors	
	1	2
New products	**0.520**	0.368
New machinery or equipment	0.310	**0.843**
New software	0.287	**0.852**
New intermediate inputs	**0.635**	0.238
New production processes	**0.722**	0.175
New markets	**0.722**	0.098
New organisation	**0.568**	0.221
New firm image or product presentation	**0.607**	0.333

As can be seen, the second factor is mainly correlated with the introduction of new machinery and equipment and new software, whereas the first factor is correlated mainly with the other 6 innovation activities. The first factor captures internal innovativeness as a latent dimension of the SME's performance, whereas the second factor captures the SMEs' behaviour regarding the adoption of technology generated in other firms or institutions. This result confirms hypothesis H1, proposed in Section 2.

As stated previously, an oblimin rotation was used in order to allow for a certain correlation between the components obtained in this analysis. Hence, a statistical relationship is observed between these two factors or dimensions of the SMEs' innovation-related activities, given by a 0.340 correlation coefficient. Consequently, those SMEs that do more to internally develop innovative improvements are, to some extent, more active in terms of external technology absorption.

[3] The value of the Kaiser-Meyer-Olkin statistic is 0.782 and the Bartlett's sphericity test shows a significant value for the Chi-square, confirming that the correlation matrix is non-random.

4.2. Regression results

The results of the estimation of the linear regression models are now presented: firstly, for the case of the core innovation latent variable obtained as the first component in the principal component analysis; and subsequently for the case of the second principal component, which is associated with technology adoption processes.[4] In both cases, two models were estimated: the first model, with only the control variables and the variables related to the entrepreneur's personal characteristics; the second model, with the variables for business characteristics added.

Table 4 shows the results from the regression models for the first component that captures the core latent innovativeness dimension of the SME's activity.

Table 4. Linear regression for innovation

(1st factor derived from the principal component analysis)

	(1)				(2)			
	β	S.E.	St. *β*	Sig.	*β*	S.E.	St. *β*	Sig.
Constant	-1.171	0.126		***	-1.489	0.122		***
Control variables								
emp	0.021	0.004	0.286	***	0.009	0.003	0.116	**
emp2	-0.000	0.000	-0.187	***	-0.000	0.000	-0.083	*
ind	0.340	0.083	0.105	***	0.273	0.077	0.085	***
serv	0.014	0.052	0.007		-0.044	0.049	-0.022	
Personal characteristics								
edu	0.053	0.021	0.061	**	-0.008	0.020	-0.010	
int_mot	0.039	0.012	0.081	***	0.027	0.011	0.057	**
ambition	0.067	0.012	0.134	***	0.044	0.011	0.088	***
risk	0.067	0.013	0.126	***	0.045	0.012	0.086	***
Business characteristics								
inn_exp					0.436	0.049	0.206	***
train					0.128	0.053	0.058	**
plan					0.336	0.048	0.167	***
r&d_coo					0.127	0.038	0.079	***
fair					0.172	0.051	0.078	***
client					0.229	0.047	0.114	***
consult					0.035	0.049	0.017	
Adjusted *R* squared			0.093				0.229	
n = 1,583 valid cases								

β = Unstandardised regression coefficients. St. *β* = Standardised regression coefficients. S.E.=Standard Error

* Differences statistically significant at the 0.10 level. ** Differences statistically significant at the 0.05 level. *** Differences statistically significant at the 0.01 level.

As can be observed in Table 4, the SMEs that operate in the industrial sector and those with a larger number of employees show higher levels of core innovation. However, the coefficient for the

[4] The condition indices are lower than 20, so there is no serious problem of multicollinearity in the analysis.

squared number of employees is negative, and is significant in Model 1 and only marginally significant in Model 2.

All the variables capturing the entrepreneur's personal characteristics are statistically significant in the models in Table 4. The only exception is the variable for education in the larger model (Model 2). Nevertheless, this appears as a highly significant variable in the first model. Regarding the business characteristics, all are statistically significant in the model, with the exception of the variable that captures the use of external consultancy services.

Table 5 shows the results when taking the second principal component as a dependent variable in the regression models. This factor captures the activities for technology adoption.

Table 5. Linear regression for technology adoption

(2nd factor derived from the principal component analysis)

	(1)				(2)			
	β	S.E.	St. *β*	Sig.	*β*	S.E.	St. *β*	Sig.
Constant	-1.234	0.127		***	-1.618	0.123		***
Control variables								
emp	0.020	0.004	0.274	***	0.009	0.003	0.125	***
emp2	-0.000	0.000	-0.184	***	-0.000	0.000	-0.090	**
ind	-0.026	0.083	-0.008		-0.055	0.077	-0.017	
serv	0.162	0.052	0.081	***	0.103	0.049	0.051	**
Personal characteristics								
edu	0.153	0.021	0.176	***	0.110	0.020	0.126	***
int_mot	0.020	0.012	0.041	*	0.009	0.011	0.018	
ambition	0.028	0.012	0.055	**	0.012	0.011	0.023	
risk	0.054	0.013	0.102	***	0.035	0.012	0.067	***
Business characteristics								
inn_exp					0.566	0.050	0.268	***
train					0.214	0.053	0.097	***
plan					0.077	0.048	0.038	
r&d_coo					0.061	0.038	0.037	
fair					0.168	0.051	0.076	***
client					0.139	0.047	0.069	***
consult					0.113	0.049	0.053	**
Adjusted *R* squared			0.086				0.215	
n = 1,583 valid cases								

β = Unstandardised regression coefficients. St. *β* = Standardised regression coefficients. S.E.=Standard Error

* Differences statistically significant at the 0.10 level. ** Differences statistically significant at the 0.05 level. *** Differences statistically significant at the 0.01 level.

The results show the service sector variable with a positive and statistically significant coefficient in Models 1 and 2. Both the number of employees and the squared number of employees are significant in the models, the sign of the quadratic terms being negative. Regarding the personal characteristics, only education and risk-taking are significant in the final model. The ambition for growth and intrinsic motivation are significant only in the baseline model (Model 1 in Table 5) which only

includes the control variables and personal characteristics (intrinsic motivation is only marginally significant in this model). All the business characteristics, whether they be internal or external, present statistically significant effects in Model 2, with the exception of business planning and cooperation in R&D with universities and other research institutions. In this case, the access to consultancy services presents a significant positive coefficient in the model in contrast with the results for the core dimension of SMEs' innovativeness.

Generally speaking, these results uphold hypothesis H2, as the entrepreneur's personal characteristics influence the two latent dimensions of innovativeness in SMEs differently, although the importance of risk-taking remains for both dimensions. Furthermore, hypotheses H3 and H4 can be partially accepted. Differences exist in the influence of business planning (as an internal organisational factor) and R&D cooperation and consultancy services (as external sources of innovation) on the two dimensions of SMEs' innovativeness.

5. DISCUSSION AND CONCLUSION

This paper addresses the determinants of innovation in SMEs from a broad and integrating perspective, and considers technological and non-technological (marketing or organisational) forms of innovation, and worldwide, 'new-to-market' and merely 'new-to-firm' innovations. The innovativeness of the approach stems from the identification of the latent dimensions behind this broad scope of innovation-related activities. The paper hypothesises that the observed range of innovation outcomes is the result of certain unobserved dimensions that shape the firm`s approach to innovation.

The principal component analysis carried out has enabled the identification of two main latent factors: the first captures the core dimension of a firm's innovativeness and the second its technology adoption activities. In this respect, the paper contributes to the literature by empirically delimiting these two dimensions, based on the data and not on the theory. Moreover, this approach enables the analysis of the differences in the factors that condition these two dimensions of an SME's innovativeness. In this respect, two main groups of conditioning aspects are identified: the personal characteristics of the business owner/manager, and the business characteristics. In addition, within this second category, two aspects can be observed: on the one hand, the internal capacity to innovate; and, on the other hand, the access to external resources of knowledge for innovation.

The results presented in the paper can be discussed in the light of the previous literature. When considering the capabilities for core innovation, the fact that the SMEs in the industrial sector are more innovative confirms the influence of the sector on innovation in companies, as observed in previous studies (Arundel and Kabla, 1998; Tödtling and Trippl, 2005). With respect to the entrepreneur's personal characteristics, the low relevance of education as a determinant of core innovation stands out, in contrast with previous research that has observed significant effects of the entrepreneur's education on business innovation (Koellinger, 2008; Marvel and Lumpkin, 2007). Nevertheless, this variable appears as highly significant in the model that only includes the control variables and the personal characteristics of the entrepreneur. This could be due to a strong relationship between the entrepreneur's education and the type of management of their business. Once the latter aspect is considered in the regression model, the residual effect of education can be disregarded. This is in line with the results obtained by Romero and Martínez-Román (2012) in a study of the innovation activities of the self-employed. The results also indicate that entrepreneurs with an intrinsic motivation, ambition for growth, and a risk-taking predisposition stimulate the core dimension of SMEs' innovativeness.

The SMEs' internal capability for introducing innovations is positively influenced by the R&D investment, business planning, and the training activities for workers. Furthermore, R&D cooperation with Universities and technological centres, participation in trade fairs and conferences, and suggestions or petitions from clients all represent external sources of information that foster this core dimension of innovativeness in SMEs. In this respect, the positive influence of clients seems to carry even more importance than R&D cooperation, according to the values of the standardised regression coefficients. However, the use of external consultancy services, whose importance has been pointed out in previous research (Yam et al., 2011), appears to exert no significant effect on core innovation.

Moreover, this study provides results regarding the capabilities for technology adoption. In this respect, those businesses which operate in the service sectors are observed to be more active than the rest in terms of technology adoption. This result confirms the importance of new technologies in services, even in those with a lower technological content (Romero and Martínez-Román, 2015).

Regarding the personal characteristics, only education and risk-taking are significant for technology adoption in SMEs. This is in line with previous research (Autry et al., 2010; Correa et al., 2010; Romero and Martínez-Román, 2015). Therefore, the results suggest that the capabilities for technology adoption

are mainly related to the knowledge and skills acquired through the education process (as the size of the standardised coefficient for the education variable also confirms).

According to the econometric analysis, technology adoption seems to require internal capabilities associated with education and training, but is less demanding in terms of organisation complexity and managerial resources. The access to external sources of innovation is highly important for technology adoption, but the most important information in this respect is the specific professional and technical knowledge that can be obtained from clients and consultants operating in the sector. On the other hand, scientific knowledge of a more general nature that is generated in Universities and R&D centres is irrelevant for the technology adoption dimension. This finding differs from the results of other studies (Gil et al., 2012), perhaps because of the particular relationships that SMEs tend to have with these technological agents (Kaufmann and Tödtling, 2002).

Overall, these results clearly show that differences exist in the determinants of core innovation and technology adoption. The core dimension of innovativeness is directly associated with entrepreneurs' motivations and personal attitudes towards risk and growth. However, when specifically considering the firm's capacity for technology adoption, the entrepreneur's motivation and economic ambition hold no relevance, whereas the education background appears as the most significant factor.

Furthermore, differences also exist in the determinants of core innovation and technology adoption regarding the organisational characteristics. Thus, business planning is observed to be a very important factor for the core dimension of SMEs' innovativeness in line with previous literature (Kapsali, 2008; Salomo et al., 2009), whereas it is not relevant for the technology adoption processes. This shows that the project management associated with the core dimension of innovation may require greater efficiency in internal organization processes. Differences also exist in the case of the external resources for innovation. Thus, when considering the core dimension of the SME's innovativeness, the use of external consultancy services seems to have no significant effect on innovation, whereas this is observed to be a relevant factor for technology adoption. Furthermore, cooperation in R&D with universities and technological centres fails to increase the SME's capacity for technology adoption, whereas it does have a significant effect on the core innovation capabilities.

In addition, as suggested in previous studies, the results indicate that firm size is positively related to the two dimensions of innovativeness (core innovation and technology adoption) (Amara et al., 2008; Lin, 2014), and this relationship is concave downwards (Martínez-Román et al., 2011; Romero and

Martínez-Román, 2012). Larger firm sizes favour the availability of the resources necessary for innovation (human resources, financial resources, organisational resources, etc.). Nevertheless, the positive effect of firm size on core innovation decreases as the number of employees increases. The complexity and bureaucracy in larger SMEs generate inertias and rigidities that run against innovation, thereby partially offsetting the advantages associated with a larger firm size.

These results suggest that innovation policy should consider specific actions depending on the target of their interventions. If the objective is the stimulation of high-growth innovating firms, policy makers should focus on entrepreneurs with a ambition for growth and intrinsic motivation and support R&D investment and adequate business planning. However, when striving to advance SMEs towards the technical efficient frontier by means of technology adoption, policy makers should take into account the fact that the capabilities for technology adoption seem to be directly associated with the entrepreneurs' education. Moreover, facilitating access to consultancy services for innovation emerges as a strategic line of intervention in this case.

Finally, several ideas can be proposed for future research. The results of this work refer solely to Spain and cannot therefore be generalized. However, the methodology proposed can be applied in comparative studies of the basic dimensions of innovation and its determinants in different regions, countries, and sectors. This analysis could lead to conclusions of a more general nature. Furthermore, the results obtained regarding firm size should be confirmed in other studies that include larger companies. Another extension could be the study of the individual and interaction effects of the two basic dimensions of innovativeness on business performance.

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