Inbound open innovation in SMEs: indicators, non-financial outcomes and entry-timing

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Abstract: This study contributes to the literature on inbound open innovation in three ways. Firstly, it verifies the suitability of three groups of innovation activities (external information sources, cooperation, and acquisition of machinery, knowledge or R&D) as indicators of open innovation, by modelling their relationship with the openness of the development of new products. Secondly, it relates these activities to three non-financial product-oriented outcomes of SMEs: quality, product range, and market share. When significant, the signs of the relationships are always positive. Thirdly, it is the first to link two streams of the literature on innovation within SMEs: open innovation and entry-timing. We distinguish between pioneers (the first to introduce innovations onto the market) and followers and find that most open innovation activities relate to the pioneering behaviour. This should be taken into consideration when designing public policies supporting innovation. Data include Spanish innovative SMEs from the Community Innovation Survey.

1. Introduction

Open innovation has become increasingly popular in the literature (Dahlander and Gann 2010; Giannopoulou et al. 2010; Huizingh 2011; West and Bogers 2014) since Chesbrough coined the phrase in 2003. According to Chesbrough (2003), open innovation is a model in which the boundaries between the firm and its environment become flexible, allowing for a two-way flow of knowledge from inside the firm out (outbound) and from outside in (inbound).

In this article we focus on inbound open innovation for two reasons. The first is that inbound practices are the ones that allow firms to access and benefit from external knowledge, thus improving not only their competitiveness but also their innovative performance (Chesbrough 2003; Christensen et al. 2005; Huizingh 2011; Spithoven et al. 2013). The second is that inbound open innovation practices are the prevalent open innovation practices in SMEs (Van de Vrande et al. 2009).

Despite the fact that there have been a large number of studies in this field over the past decade, some issues still need further clarification. For instance, West et al. (2014) and Zeng et al. (2010) suggest the need for further research on the measurement of open innovation. Refining the role of inbound open innovation activities as open innovation indicators would contribute to this goal. To this end, we assess the relevance of a range of inbound open innovation practices to the degree of openness of the development of new products, thus contributing validity evidence to the existing empirical work.

Furthermore, there is no consensus in the literature as to the sign of the effects of open innovation practices on innovation results. The majority of studies sustain that there is a positive relationship between inbound open innovation activities and innovation outcomes (see Faems et al. 2005; Parida et al. 2012, amongst many others). However, other studies (for example, Laursen and Salter 2006; Torkkeli et al. 2009) show that the effects of this relationship can also be negative. Accordingly, in line with the paragraph above, more research work can be done on innovation outcomes in an open context.

Moreover, West et al. (2014) and Huizing (2011) suggest that there is a need to continue the stream of studies that link open innovation and established theories of innovation,

management and economics. With the origins of open innovation being based on case studies, recent articles on this area of research have sought to test its empirical validity on large samples in the light of different academic theories. As an example of business strategy related to innovation, entry timing (as a first mover or pioneer –first to introduce innovations onto the market– or as a follower –imitator–) has long attracted academic and managerial interest (Lieberman and Montgomery 1988; 1998; 2013). Entry-timing studies call for further research to check its context dependence (Zachary et al. 2015). The open innovation context, which increases the availability of information and the velocity of its diffusion (Dahlander and Gann 2010), is a new scenario where the roles of pioneers and followers need to be reexamined. The results of this analysis can be useful in helping the design of public policies supporting innovation, by shedding light on whether pioneer or follower firms can benefit most from open innovation.

At the beginning, the literature on open innovation centred on large firms (Chesbrough 2003; Dodgson et al. 2006; Kirschbaum 2005), but since then various authors have suggested that open innovation practices may also strategically benefit SMEs (Parida et al. 2012; Spithoven et al. 2013; Van de Vrande et al. 2009). Huizingh (2011) and Spithoven et al. (2013) highlight that SMEs may precisely have interest in opening up their innovation processes to overcome their limited resources, that is, as a means "to overcome their 'liability of smallness'" (Gassman et al. 2010, 216). The few recent studies using large-scale data suggest that the importance of open innovation in SMEs will tend to increase over time (Van de Vrande et al. 2009), maybe lagging behind large firms (Huizingh 2011). According to Spithoven et al. (2013), if we think in relative terms (i.e., the ratio of open innovation activities over employment) SMEs have already caught up.

Given the fact that SMEs continue to be underresearched in the open innovation literature (Gassman et al. 2010; Vanhaverbeke et al. 2014; West et al. 2014) while playing an important role in the business landscape of many countries (Eurostat 2013; OECD 2005), it is important that the nature of open innovation in these firms is studied in greater depth. Accordingly, Huizing (2011) and West et al. (2014) suggest that there is a need for further research of open innovation in SMEs using large-scale data. The few available related studies estimate the effect of aggregated measures on openness

rather than the effects of each particular open innovation activity (Barge-Gil 2013; Parida et al. 2012; Spithoven et al. 2013; Zeng et al. 2010). The Spanish context is an ideal testing ground for SME studies, given their important presence in the economy as a whole (Eurostat 2013; OECD 2005).

This study aims to shed light on some of these gaps in the research on inbound open innovation. More specifically, it contributes to existing literature in three ways in the context of Spanish SMEs. Firstly, to verify the suitability of the selected inbound innovation activities as indicators of open and closed innovation we model their relationship with the degree of openness in the development of new products. Secondly, we measure the effect of the various open innovation activities –cooperation partners, external sources of information, R&D, machinery and knowledge acquisition– on three non-financial product-oriented outcomes: quality, product range and market share. Thirdly, we link two streams from the innovation literature –open innovation and entry-timing– and we study their relationship empirically.

This article is structured in the following way: Section 2 is a brief overview of the theoretical and empirical literature on inbound open innovation and on entry-timing; the data and methodology used are presented in section 3; section 4 contains the results; and in sections 5 and 6 we comment on the results and draw conclusions, as well as discuss the limitations of this study and make suggestions for further research.

2. Review of the literature

2.1 Inbound open innovation activities and firm performance

Many studies classify open innovation into two groups: outbound activities and inbound activities: (Chesbrough 2003; Dahlander and Gann 2010; Huizingh 2011). Outbound practices are the processes by which companies reveal information or sell their technology (Chesbrough 2006; Faems et al. 2010; Lichtenthaler 2015; West and Bogers 2014). Conversely, inbound practices refer to the firm's capacity to obtain and explore knowledge from external sources (Barge-Gil 2010; Cruz-González et al. 2015; Laursen

and Salter 2006; Van de Vrande et al. 2009; Zang et al. 2014). Empirical research has repeatedly found a higher prevalence of inbound activities (Huizingh 2011) also in SMEs (van de Vrande et al. 2009). This may be due to "its greater popularity among managers, either as a cost-reduction measure or because more firms are in a position to use technology than to create it" (West et al. 2014, 806).

The precedents of inbound open innovation can be found in the studies that analyse the use, individually, of external sources of knowledge such as clients (Von Hippel 1986), suppliers (Ragatz et al. 2002), competitors (Bengtsson and Kock 2000; Grimpe and Sofka 2009), and universities (Grimpe and Sofka 2009; Santoro and Gopalakrishnan 2000) in the innovation process.

More recently, many studies have analysed the relationship between innovation practices and the simultaneous use of a wide range of external sources of knowledge (Huizingh 2011). Some of these have focused their analyses on cooperation practices (Barge-Gil 2010; Becker and Dietz 2004; Faems et al. 2005; Parida et al. 2012); others on the use of external sources of information (Cruz-González et al. 2015; Grimpe and Sofka 2009; Laursen and Salter 2006; Leiponen and Helfat 2010), and others on the practices of acquiring external R&D, machinery, etc. (Chesbrough and Crowther 2006; Frenz and Ietto-Gillies 2009; Van de Vrande et al. 2006). Moreover, other studies have incorporated several of these groups of activities together (Spithoven et al. 2013; Van de Vrande et al. 2009).

Overall, the past years have witnessed a surge in empirical studies that centre on open innovation activities in general and of inbound open innovation activities in particular. The European-wide availability of the Community Innovation Survey (CIS) data has contributed to the range of indicators that are currently being widely used. Even if they contain a limited range of open innovation practices and lack in outbound practices, the CIS data have been held as standardised, comparable, representative and, most importantly, trustworthy (Laursen and Salter 2006). Even though the studies using CIS data have contributed greatly to the widening of our knowledge about open innovation there are still areas that need to be studied in further depth. For instance, no test has been provided on the adequacy and validity of the CIS inbound indicators as proxies for the degree of openness of new products. According to Love et al. (2011), inbound open innovation activities and open new product development are the first and the last stage

of the same open innovation process. In this respect, we aim to relate the said inbound open innovation practices with a direct measure of the degree of openness in the development of new products and put forward the following hypotheses (see Figure 1):

H1a: Cooperation practices have a positive effect on the degree of openness in the development of new products.

H1b: The use of external sources of information has a positive effect on the degree of openness in the in the development of new products.

H1c: The practices of acquiring external R&D, machinery or knowledge have a positive effect in the degree of openness in the in the development of new products.

The above hypotheses must be understood from the perspective of testing the measurement validity of the CIS inbound open innovation practices. In order for the CIS inbound open innovation practices to be valid, they should predict the direct measure of openness in product development which acts as a criterion. This is referred to with the closely related terms of predictive validity and criterion-related validity (Carmines and Zeller 1979).

In what follows, hypotheses relate to theoretical relationships between open innovation and other variables which can be thought to be outcomes in innovation. The most commonly used outcome indicators in the open innovation literature are financial profitability (for example, Belderbos et al. 2004; Faems et al. 2010; Sisodiya et al. 2013) and the percentage of turnover coming from new products (for example, Cheng and Shiu 2015; Laursen and Salter 2006; Parida et al. 2012; Spithoven et al. 2013). In traditional innovation research the addition of non-financial indicators tends to be favoured (see for instance Nieto and Santamaria 2007; Tsai 2009; Zeng et al. 2010). When asked in an open question format, managers in the study by Van de Vrande et al. (2009) frequently identified market issues as one of the most important motives for open innovation practices. We thus add to the literature on open innovation by using three non-financial product-oriented outputs (increased product quality, product range and market share).

Most of the aforementioned analyses, as well as other relevant studies (Bae and Chang 2012; Chiang and Hung 2010; Huang et al. 2015), have found a positive relationship between the different inbound innovation activities and innovation performance, albeit without complete consensus in the literature (see Lauren and Salter, 2006, Torkkeli et al., 2009, for some reported negative signs). The benefits of open innovation are also the prevalent finding in studies that focus on SMEs (Barge-Gil 2013; Parida et al. 2012; Spithoven et al. 2013; Zeng et al. 2010). Accordingly, we put forward the following hypotheses:

H2a: Cooperation practices have a positive effect on the innovation outcomes.

H2b: The use of external sources of information has a positive effect on the innovation outcomes

H2c: The practices of acquiring external R&D, machinery or knowledge have a positive effect on the innovation outcomes.

2.2 Open innovation and entry-timing strategies

Imitation of superior products and processes is widely recognized as a fundamental part of both innovation and competition. A related body of the literature refers to the decision on whether to be the first to introduce a product into the market, i.e. the so-called entry timing decision (Lieberman and Asaba 2006). Successful (or less successful) pioneers end up facing the subsequent competition of imitative followers in as much as information leaks or spills over (Mansfield 1985). According to Cappelli et al. (2014), in an open innovation context, the speed and amount of spillovers can only increase over time; some spillovers will serve imitation while other may also serve innovation.

Over the last two decades many researchers in the fields of marketing strategy and economics have meaningfully contributed to the entry-timing theory (e.g. Boulding and Christen 2008; Lieberman and Montgomery 1988; 2013; Min et al. 2006; Zachary et al. 2015). The majority of these studies have focused their analyses on the possible advantages and disadvantages for companies of an early entry onto the market.

Pioneer firms can potentially widen markets, shape consumer preferences and even influence changes in consumer behaviour. These changes may be essential to be able to maintain the firm's competitive position and they are an opportunity to promote the attributes that boost their brand (Boulding and Christen 2008; Lieberman and Montgomery 1988; Zachary et al. 2015). Min et al. (2006) suggest that consumers maintain a long-term preference for pioneer brands, associating them with values such as authenticity and innovation. Furthermore, pioneers can reap the benefits of economies of scale and learning (Robinson and Min 2002), and they can get a head start on their rivals to acquire scarce resources, thus increasing their market share (Min et al. 2006; Zachary et al. 2015).

However, a follower strategy also has its advantages. Firstly, the costs involved in imitation are often lower than the cost of innovation given the fact that the existing products provide the information necessary for imitative product development (Boulding and Christen 2008; Min et al. 2006; Reed and DeFillippi 1990). On the other hand, a market is generally not well defined in the initial stages and this makes it difficult for innovators to act strategically with success. Followers are able to obtain more information about the product from the innovator and improve it, thus serving customers more effectively (Boulding and Christen 2008; Lieberman and Asaba 2006).

Results favouring one or the other of the two strategies are not at all conclusive and they often report countervailing findings on the grounds of contingency effects (e.g. Min et al. 2006; Zachary et al. 2015). A related issue are the determinants of the choice between being early or late entrant, which are also context dependent (Lévesque et al. 2013).

In an extensive review, Zachary et al. (2015) propose to conduct further research on the context dependence of entry-timing. The alleged context dependence of entry-timing suggests the suitability of reexamining it within SMEs in an open innovation context. In a work similar to ours, Cappelli et al. (2014) considered external information sources in German manufacturing firms regardless of size. We make a first attempt at linking open innovation and SME's entry-timing by relating the various groups of inbound open innovation activities to the pioneering introduction of innovations into a market. On the one hand, the larger ease of use of external resources and information sources that

characterize open contexts may increase the capacity to introduce products new to a firm's market (by pioneers). On the other hand, this larger ease of use can also facilitate the reproduction of already extant products (by followers). Cappelli et al. (2014) report effects in both directions. Overall, Chesbrough and Crowther's (2006, 1) words referring to what is core to the open innovation model: "…the recognition that today, competitive advantage often comes from *inbound open innovation*,…[italics are as in the cited source]" leads us to hypothesize a positive relationship between the use of inbound open innovation activities and being the first to introduce an innovation onto a firm's market. Therefore we suggest the following hypotheses:

H3a: Cooperation practices lead to an increased likelihood of early introduction of new products onto the market.

H3b: The use of external sources of information leads to an increased likelihood of early introduction of new products onto the market.

H3c: The practices of acquiring external R&D, machinery or knowledge lead to an increased likelihood of early introduction of new products onto the market.

Hypotheses are summarized in Figure 1.

3. Data and methods

3.1 Data

Data from the Eurostat Community Innovation Surveys (CIS) carried out in Spain are used to analyse the relationship between inbound open innovation activities of SMEs, open development of new products, innovation outcomes and entry-timing. In particular, we use the 2004 and 2006 waves which contain a battery of innovation outcome questions under the heading "Effects of innovation during [the three previous years to the interview]" that later available waves (2008, 2010 and 2012) did not include. The decision to use Spanish data was based on the fact that SMEs in Spain constitute more than 98% of the business world (Eurostat 2013). The sample includes firms between 10 and 249 employees from all sectors of the manufacturing and service

industries classified either as small firms (10-49 employees) or medium-sized firms (50-249 employees) according to the Oslo Manual (OECD 2005, 71).

Of those surveyed only individual firms that claimed to have carried out a product or service innovation in the two years immediately prior to the survey have been taken into account. Firms belonging to a business group in the CIS are those which are legally defined and under common ownership regardless of whether they serve the same market or not. These firms have been excluded for two reasons. Firstly, transference of knowledge, information or R&D resources between companies from the same group could lead to a distortion of the effects of innovative performance or to confusion as to whether certain activities carried out outside the firm but within the group are open or closed. Secondly, a small firm in a large group shares many characteristics of large firms in terms of access to complex resources and funding, for example.

Having excluded cases with missing data we have identified 8,682 individual companies who affirm that they have carried out at least one innovation activity related to a product or service in the 2004 and 2006 surveys, 69% of which are small and 31% medium-sized firms.

3.1.1 Dependent variables

With the purpose of confirming the relevance and validity of the selected inbound open innovation activities, the first dependent variable measures the degree of openness in the development of new products and services. The CIS survey asked the firms about who had developed the new products and services. We assign 1 to the answers, “Your enterprise together with other enterprises or institutions” and “Mainly other enterprises and institutions”, and we assign 0 to the answer “Mainly your enterprise […]”.

The second dependent variable we consider is the outcomes obtained from the innovative products and services. In the CIS surveys of 2004 and 2006 the general question, “How important were each of the following effects of your product (good or service) innovations during [the three years prior to the interview]" was asked. Answers are recorded from 0 to 3, where 0 represents ‘not relevant’, 1 ‘low’, 2 ‘medium’ and 3 ‘high.’ We select the variables directed at the following non-financial outcomes of product and service innovations: (1) improved quality, (2) increased range of

goods/services, and (3) increased market share. We construct the dependent variable as the count of outcomes for which the effect is at least 'medium'.

The third dependent variable measures the market entry-timing of the innovated products according to the question "Your enterprise introduced a new or significantly improved good or service onto your market before your competitors -it may have already been available in other markets?", which was coded as 1 when the firm answered 'Yes' (first mover) and as 0 when the firm answered 'No'. Other studies in the literature on open innovation have used the same variable to relate it to the degree of novelty of the innovations (radical versus incremental; see for instance, Laursen and Salter 2006; Parida et al. 2012). We believe that the wording of the question better fits the entry-timing concept.

3.1.2 Independent variables

As explained in the literature review section, we include in our analysis a wide range of open inbound innovation activities from three groups: cooperation, information sources and acquisition: cooperation with suppliers, cooperation with customers, cooperation with competitors, information sources from consultants, information sources from universities and public institutions, acquisition of external R&D, acquisition of machinery, and acquisition of external knowledge. In order to distinguish between open innovators and innovators as a whole, we include two internal innovation activities as controls: internal information sources from within the enterprise and internal R&D.

These variables, together or in narrower groups, have been used previously in the open innovation literature (Frenz and Ietto-Gillies 2009; Grimpe and Sofka 2009; Laursen and Salter 2006; Lichtenthaler 2008; Spithoven et al. 2013; Van de Vrande et al. 2009). The first narrower group of variables measures cooperation, which is related to active participation in innovation activities with other enterprises or non-commercial institutions. The second narrower group corresponds to the variables related to information gathering, which are 'soft' in the sense that they do not necessarily require formal contracts or monetary resources. And finally, the third narrower group includes the variables acquisition of machinery, acquisition of external knowledge and of external R&D, which imply monetary expenses. The literature on open innovation in

SMEs has thus far computed aggregated composite measures of open innovation activity (e.g. the total or average of all questions on information sources, of all questions on cooperation; factor scores; or just one open innovation indicator; see Barge-Gil 2013; Parida et al. 2012; Spithoven et al. 2013; Zeng et al. 2010). Aggregated measures of several activities assume that all aggregated activities have a similar effect on the dependent variable. This is an assumption we do not wish to make in this article and therefore we include each activity as a separate variable.

We converted all the variables into binaries. The variables related to expenditure (internal R&D, acquisition of external R&D, acquisition of machinery and acquisition of external knowledge) were already binary in the CIS survey (1=Yes, 0=No). For the information sources the categories 'Not used' and 'Low' were grouped together (0) and the categories 'Medium' and 'High' were grouped together (1). For the cooperation variables the category 'Yes' (1) included any cooperation regardless of geographical location.

We use the size of the firm as control variable: small firms are coded as 1 and medium-sized ones as 0. Additional controls include the year of the survey (2004=1 and 2006=0) and the activity sector (NACE code grouped into 24 categories).

Table 1 shows the frequencies of all the variables broken down by firm size.

3.2 Statistical analysis

The relationship between each of the dependent variables, the activities and the controls is specified as an ordered logistic regression model (e.g., Borooah 2002; Fullerton 2009). The model is specified as:

$$y_i^* = \mathbf{x_i}\boldsymbol{\beta} + u_i$$

where y_i^* is an underlying continuous dependent variable, which is not observed. The categorized y_i with K categories is observed instead as $y_i=0$ if $y_i^* \leq \tau_1$; $y_i=1$ if $\tau_1 < y_i^* \leq \tau_2$; $y_i=2$ if $\tau_2 < y_i^* \leq \tau_3$; …; $y_i=K-1$ if $\tau_{K-1} < y_i$. y_i^* thus shows the propensity for developing innovations more openly, for more successful outcomes, or for being more of a first

mover. **x** is a row vector of explanatory variables, which in our case includes dummy coded open innovation activities and controls. β stands for the coefficient vector. u_i is a disturbance term with a logistic distribution.

It must be noted that a binary logit model is a particular case of the ordered model with K=2. This makes it possible to analyse all the dependent variables in this article within a common framework.

4. Results

According to Table 2, the Nagelkerke's R-squared of the effects of the innovation activities on the three logit models for each dependent variable (open development of new products, innovation outcomes and entry-timing) are 0.221, 0.283 and 0.225 respectively. These results are comparable to those encountered in the literature predicting binary or ordered innovation outcomes from open innovation practices (between 0.07 and 0.18 in Spithoven et al. 2013; between 0.19 and 0.20 in Leiponen and Helfat 2010; between 0.24 and 0.26 in Becker and Dietz 2004).

4.1 Inbound innovation activities and open development of introduced products

In the first model we have measured the effects of innovation activities on how new products are developed. The results confirm that new products have been developed in an open way through the following activities: cooperation with suppliers ($\hat{\beta}$=1.480; p<.001), cooperation with customers ($\hat{\beta}$=.320; p<.01), cooperation with competitors ($\hat{\beta}$=.752; p<.001), information from consultants ($\hat{\beta}$=.351; p<.001), information from universities and public institutions ($\hat{\beta}$=.488; p<.001) and acquisition of external R&D ($\hat{\beta}$=.917; p<.001). These results show that the selected inbound open innovation activities included in the CIS survey have a positive effect on the fact that the new products/services have been developed in an open way. This argues for the measurement validity of the said indicators and supports hypotheses H1a to H1c. The most valid openness indicators according to our results are cooperation with suppliers, cooperation with competitors and acquisition of external R&D.

Only the acquisition of machinery and of external knowledge fail to have a significant effect on the open development of new products/services. In this particular equation, the controls referring to closed innovation practices are conceptually interpretable and both of them lead to a reduction in the likelihood of new products being developed openly ($\hat{\beta}$=–0.243, p<.01; $\hat{\beta}$=–1.055, p<.001).

4.2 Inbound innovation activities and innovation outcomes

In the second model we have measured the effects of innovation activities (open or closed) on the count of non-financial outcomes with at least medium innovation effect.

As regards cooperation (H2a) we have found that at least one cooperation activity has a significant positive effect (cooperation with customers: $\hat{\beta}$=.309; p< .001). Cooperating with suppliers and competitors does not have a significant effect on the innovation outcomes. H2a is thus partly confirmed and customers have been shown to be particularly relevant.

As regards external information (H2b), all effects are significant and positive (consultants: $\hat{\beta}$=.517; p< .001; universities and public institutions: $\hat{\beta}$=. 257; p< .001). H2b is thus confirmed.

As regards acquisition (H2c), only acquiring machinery has a significant positive effect on the innovation outcomes ($\hat{\beta}$=. 519; p< .001). The acquisition of knowledge and external R&D do not have a significant effect on the innovation outcomes. H2c is thus partly confirmed.

4.3 Inbound innovation activities and entry-timing

In the third model of Table 2 we measure the relationship between the innovation activities and the entry-timing of the innovations. The results show that at p-value <0.05 all but one of the open activities have a positive effect on entry-timing when introducing new products or services into the market.

All cooperation variables have a positive effect, and thus favour an early introduction of innovations (suppliers: $\hat{\beta}$=.371; p<.001; customers $\hat{\beta}$=.395; p<.001; competitors: $\hat{\beta}$=.234; p<.05), thus supporting H3a.

As regards the use of external information sources, consultants do not have any significant effect. The use of sources of information from universities or public institutions has a positive effect on the introduction of new products/services onto the market as a first-mover ($\hat{\beta}$=.357; p<.001) thus partly supporting H3b.

With respect to acquisition, all three variables favour an early entry into the market (R&D: $\hat{\beta}$=.173; p<.01; machinery: $\hat{\beta}$=.118; p<.05; and knowledge $\hat{\beta}$=.220; p<.05) thus fully supporting H3c.

5. Discussion of results

Even though the study of the effects of open innovation activities on innovation performance has become increasingly popular in the literature, the results of this relationship are not yet at all conclusive (Cheng and Shiu 2015). For this reason, one of the aims of this study is to measure and test the effects of a wide range of inbound open innovation activities on non-financial innovation performance of products/services.

We can classify the results of this study into three main issues. The first is a measurement validity issue. We confirm that inbound open innovation activities have a direct positive relationship with developing new products openly (Barge-Gil 2010; Parida et al. 2012 found similar results) and that this relationship is negative for closed activities. In short, for innovative firms inbound open innovation activities are key factors in the effectively open development of new products. Regarding the relationship between cooperation activities with suppliers and obtaining new products developed openly, a relationship about which there is no consensus in the literature (Tsai 2009), our study finds it to have the strongest positive coefficient and thus the highest predictive validity. The predictive validity of external R&D is the second highest. In line with Laursen and Salter (2006) and Spithoven et al. (2013) our analysis shows the use of a wide range of external sources in the case of open product innovators. The only

inbound open activities whose relationship could not be confirmed are acquisition of machinery and acquisition of knowledge, the latter being unusual in SMEs. In a general sense, we can therefore confirm Hypotheses H1a to H1c and state that external inbound innovation activities are valid indicators of the degree of openness of the innovations developed by SMEs.

Secondly, we can confirm Hypotheses H2a to H2c, at least partially. The results show that some inbound open activities related to acquisition, cooperation and information sources have a positive effect on the amount of innovation outcomes attained: improved quality, increased product range and increased market share. These results are in line with the findings of other studies, which identify positive effects of inbound activities on the innovation outcomes of SMEs (for example, Parida et al. 2012; Spithoven et al. 2013) while providing greater detail at the particular activity level. Information from consultants, cooperation with clients and acquisition of machinery stand out. The acquisition of knowledge and external R&D are not significant. This suggests that there is a limit to the level of openness most SMEs have achieved up to now (Huizingh 2011). In fact, the European Commission (2013) report shows that within the total expenditure on extramural R&D 21% corresponds to SMEs as opposed to 79% to large firms, whereas the proportions of total expenditure on intramural R&D are 41% and 59%, respectively. The non-conclusive results for external knowledge acquisition can also be partly explained by our lack of information about the quality of the acquired knowledge. If the quality of this knowledge is low, then it is not expected to enhance outcomes. Given the fact that activities have very different effects on performance, our decision to include each particular activity in the model rather than aggregated averages, totals or factor scores, has proved its worth.

Thirdly, we show that most of the inbound open innovation activities have a positive effect on early entry-timing when introducing innovations onto a firm's market with the exception of information from consultants (hypotheses H3a to H3c). Perhaps the most notable result of the model is the relationship of external R&D and knowledge acquisition, given the fact that, as we have indicated, these are unusual activities for SMEs, which in this case suggests that they are key characteristics in distinguishing pioneer firms within the group of innovative SMEs. Cappelli et al. (2014), focusing on

information sources only, found information from competitors to favour late entry and information from customers and research institutions early entry.

6. Conclusions

The aim of this article is to study the relationship between a wide range of open innovation activities and the open development of new products, the non-financial innovation outcomes of SMEs, and the entry-timing of these firms. To this end, we have used data from the 2004 and 2006 CIS surveys carried out in Spain and focused on a range of inbound open innovation activities related to external cooperation, external information and external acquisition.

Firstly, our results provide evidence of the validity of inbound open innovation activities of the type included in the CIS surveys as indicators of the degree of openness or closedness of innovation development in SMEs. Such evidence is relevant because the use of CIS data still has both defenders and detractors. Studies that have focused on outbound open innovation have tended to use primary data (e.g., Van de Vrande et al. 2009). However, many open innovation researchers do use the CIS data for their own work or provide additional arguments for their usefulness (e.g., Barge-Gil 2013; Frenz and Ietto-Gillies 2009; Grimpe and Sofka 2009; Laursen and Salter 2006; West et al. 2014).

Secondly, our results indicate that some open innovation activities of the three categories examined have a direct positive effect on the achieved non-financial outputs (quality of the products/services, the product portfolio range and the market share), which we introduce to the open innovation context. On the other hand, some external activities like acquiring knowledge and external R&D are not significant. Overall, the positive sign in all the effects that have shown to be significant points to the suitability of open innovation activities for the innovative performance of SMEs. This result also gives us a deeper understanding of the discrepancies in effect sign found in the open innovation literature (for example, Laursen and Salter 2006; Parida et al. 2012; Spithoven et al. 2013; Torkkeli et al. 2009).

Thirdly, it must be pointed out that our study is the first in the innovation literature to empirically relate two streams within SMEs: inbound open innovation and entry-timing. We have shown that open innovation activities have a positive effect on the pioneering introduction of innovations onto a firms' market. Entry-timing stands out for its relationship with external R&D, which seems to distinguish pioneer firms from the group of innovative SMEs but fails to relate to innovation outcomes. These results are a first attempt at characterising the pioneer/follower behaviour of SMEs in an open innovation context.

Some limitations of this study must be taken into account. Firstly, we consider a wide range of innovation activities in the analysis which, admittedly, ignores the purely outbound type. This is indeed one limitation of our study, and is related to the use of official statistics data, whose range of variables is not controlled by our research. Furthermore, the source of external innovation inputs is identified, but there is no assessment of type, quality or variety of these inputs. For instance, the rate at which open innovation inputs come into the firm or whether these inputs have led to any reconfiguration at the firm level are not taken into account. The CIS does not include detailed information on the processes through which innovation inputs turn into innovation outputs, such as new product development programs and processes, and time for innovations to reach the market. The debate on the appropriateness of the CIS survey for open innovation research is still ongoing (West et al. 2014) and hopefully we have contributed to providing some new evidence of predictive validity of some of these indicators as proxies for open innovation. On the positive side, the CIS data are gathered by official statistical offices which have the resources and knowledge to provide high quality data, they provide large cross-industry and country-wide samples, and they make it possible to replicate studies in different countries and years.

Secondly, the data used in this study are based on Spanish SMEs and therefore the results are specific to this country. The effects of innovation practices in firms from other countries could be significantly different. Further research is needed to verify whether these results can be applied to other settings. In the same vein, our results specifically focus on the innovation of products and/or services and do not include other types of innovation practiced by SMEs such as process or marketing innovations. Lastly, the data are admittedly old. The recently released 2010 and 2012 CIS waves do

not include the key battery of questions about the effects of innovation on firm non-financial outcomes, so that it was not possible to include them in our analyses.

Despite the relevance of the said limitations, we consider that the results of this research can serve managers as a guide to make safer choices as to the sort of open innovation activities that would better suit the needs and/or reality of their companies. Open innovation could be a threat to firms in the sense of lessening the appropriability of innovation results. However, our results suggest that pioneer firms do use open innovation activities and do so to a wider extent than followers. Hence, rather than hindering innovation by facilitating imitation, open innovation activities, at least in the context of Spanish SMEs, could enhance the creation of innovations. This is a most critical result that must be taken into account when designing public policies aimed at fostering innovation although, as mentioned above, we acknowledge that this result may not apply to other economies, and in particular, to economies with different degrees of technological development. In this respect, Vanhaverbeke et al. (2014) recognizes the need for further research on the application of open innovation in non-Western firms.

On the basis of our results and limitations we provide indications for future research including, first and foremost, empirical studies on the advantages and disadvantages of early entry-timing for SMEs in the open innovation context with data from other economies. Furthermore, we encourage researchers to conduct more studies on how entry-timing impacts the innovation results of SMEs. Finally, the main limitations of this article can be overcome by a study using recent primary data, with a wider selection of indicators including outbound activities, and with information on the quality of inputs and outputs and not only about their existence.

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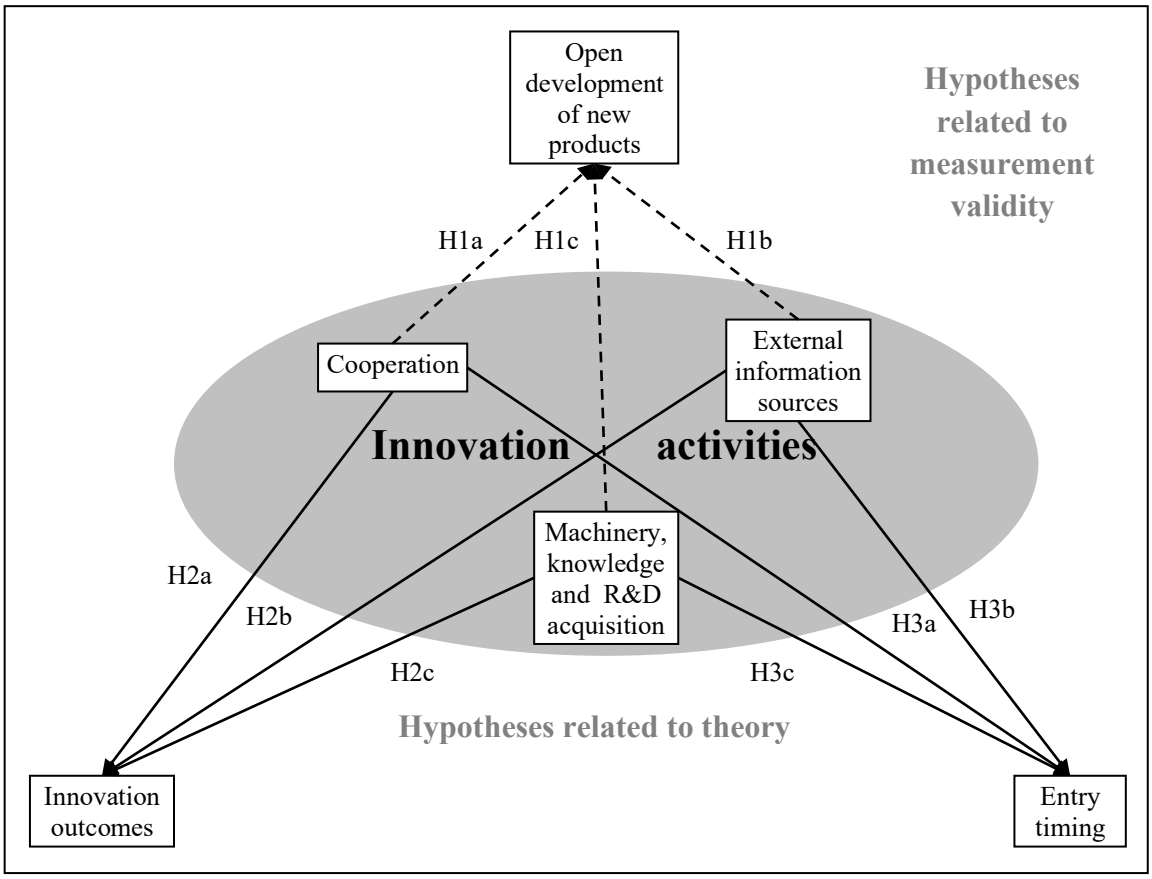

Figure 1: Summary of the hypotheses tested in this article

Table 1: Frequencies of dependent variables and innovation activities by firm size

		Small (n=5,981)	Medium (n=2,701)	Total (n=8,682)
Open development of new products	No	82.8%	78.7%	81.5%
	Yes	17.2%	21.3%	18.5%
Improved quality	Not relevant	15.5%	9.7%	13.7%
	Low	10.3%	10.6%	10.4%
	Med	29.5%	34.4%	31.0%
	High	44.8%	45.4%	45.0%
Increased range of goods/services	Not relevant	8.3%	9.2%	8.6%
	Low	22.4%	16.5%	20.6%
	Med	28.2%	31.6%	29.3%
	High	41.0%	42.7%	41.6%
Increased market share	Not relevant	20.9%	16.4%	19.5%
	Low	17.5%	18.7%	17.9%
	Med	31.8%	34.4%	32.6%
	High	29.7%	30.4%	30.0%
Overall innovation outcome (count of outcomes with at least medium effect)	0	16,6%	11,0%	14,8%
	1	13,0%	13,6%	13,2%
	2	19,3%	21,0%	19,8%
	3	51,2%	54,5%	52,2%
Entry-timing (introducing a product new to the market)	No	55.8%	51.8%	54.6%
	Yes	44.2%	48.2%	45.4%
Cooperation with suppliers	No	90.1%	84.6%	88.4%
	Yes	9.9%	15.4%	11.6%
Cooperation with customers	No	91.9%	90.0%	91.3%
	Yes	8.1%	10.0%	8.7%
Cooperation with competitors	No	94.7%	93.3%	94.3%
	Yes	5.3%	6.7%	5.7%
Information sources from consultants	No/Low	76.9%	71.6%	75.2%
	Med/High	23.1%	28.4%	24.8%
Information sources from universities and public institutions	No/Low	82.4%	78.0%	81.1%
	Med/High	17.6%	22.0%	18.9%
Acquisition of external R&D	No	75.1%	68.0%	72.9%
	Yes	24.9%	32.0%	27.1%
Acquisition of machinery	No	61.6%	59.8%	61.0%
	Yes	38.4%	40.2%	39.0%
Acquisition of external knowledge	No	93.0%	91.2%	92.4%
	Yes	7.0%	8.8%	7.6%
Internal information sources from within the enterprise	No/Low	24.4%	19.4%	22.9%
	Med/High	75.6%	80.6%	77.1%
Internal R&D	No	45.0%	34.1%	41.6%
	Yes	55.0%	65.9%	58.4%

Table 2: The relationship between open innovation activities, open development of new products, innovation outcomes, and entry-timing

	Open development of new products		Overall innovation outcome		Entry-timing	
	$\hat{\beta}$	s.e.	$\hat{\beta}$	s.e.	$\hat{\beta}$	s.e.
Cooperation with suppliers	1.480 ***	0.084	0.013	0.078	0.371 ***	0.082
Cooperation with customers	0.320 **	0.108	0.309 ***	0.097	0.395 ***	0.100
Cooperation with competitors	0.752 ***	0.117	0.180	0.109	0.234 *	0.113
Information sources from consultants	0.351 ***	0.072	0.517 ***	0.057	0.082	0.058
Information sources from universities and public institutions	0.488 ***	0.080	0.257 ***	0.065	0.357 ***	0.066
Acquisition of external R&D	0.917 ***	0.073	-0.021	0.055	0.173 **	0.057
Acquisition of machinery	0.043	0.068	0.519 ***	0.049	0.118 *	0.053
Acquisition of external knowledge	0.196	0.109	0.034	0.090	0.220 *	0.094
Control variables[1]						
Internal information sources from within the enterprise	-0.243 **	0.077	1.587 ***	0.054	0.745 ***	0.065
Internal R&D	-1.055 ***	0.079	0.696 ***	0.052	0.989 ***	0.057
Small firm	-0.182 **	0.065	-0.040	0.048	0.019	0.052
2004	0.312 ***	0.068	0.186 ***	0.049	-0.107 *	0.053
Nagelkerke's R-squared	0.221		0.283		0.225	

[1] NACE not shown

*** p-value <0.001; ** p-value <0.01; * p-value <0.05