Contextual effects in open innovation:

A multi-country comparison

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Abstract

This article contributes to the understanding of the context dependency of open innovation. It does so by empirically analysing the relationship between innovation activities, firm characteristics and the degree of innovation openness of manufacturing companies in three European countries with varying degrees of technological development. Logistic regression analysis is used to study CIS data from Germany, Portugal and Bulgaria. In line with the contingency approach to open innovation, the results suggest that the appropriate open innovation strategy is context dependent, with similar practices and firm characteristics obtaining opposite relationship signs in different countries. Hence, it is important to take country idiosyncrasies into account when designing policies to promote open innovation.

1. Introduction

This paper intends to shed light on how open innovation in companies can vary depending on the level of technological development of the country. It does so by investigating the relationship between innovation activities, firm characteristics and the degree of innovation openness of manufacturing firms in Germany, Portugal and Bulgaria.

The phenomenon of open innovation has gained wide acceptance since it was first 'labelled' by Chesbrough (2003) and defined as '… the use of purposive inflows and outflows of knowledge to accelerate internal innovation and to expand the markets for external use of innovation, respectively' (Chesbrough et al., 2006:1). It is a concept that has been readily embraced by academics and practitioners alike. One of the reasons for its success is the fit of the paradigm in reflecting the changes the innovation environment has undergone over the last decade. Indeed, various phenomena related to contextual changes -globalisation and division of labour, changes in working patterns, improved market institutions for property rights, venture capital, technology standards and so on (Dahlander and Gann, 2010) - suggest the appropriateness of a new paradigm for innovation activities.

In the open innovation paradigm, organizational boundaries are porous and firms interact with their environment (Gassman, 2006; Gassman et al., 2010, Chesbrough, 2003, Huizing, 2011). Hence, it seems plausible that different external contexts relate to variances in firms` innovation practices. In this regard, this paper examines the innovation practices of manufacturing firms in Germany, Portugal and Bulgaria, who according to the European Union Innovation Scoreboard (2008) have varying degrees of technological development: this index considers Germany to be an 'innovation leader', Portugal a 'moderate innovator' and Bulgaria a 'catching-up country'.

First, this article studies the relationship between the introduction of new products and processes and firms` degree of openness in the development of the same. Second, it considers the role of innovation strategies, which we classify into innovations that are new to the market and innovations that are new to the firm, and it then relates them to the firm's degree of openness in the development of these new products and processes. Clearly, the consequences that being open may have in each case may be quite distinct (Huizing, 2011; Reed et al., 2012.

This article considers a broad range of firms' innovation activities by including both product and process innovations. Whereas product innovations have traditionally been related to market demand (providing new products or entering new markets), process innovations are normally related to the supply side of the market (aimed, for instance, at lowering costs). Until now, most of the open innovation literature has focused on product innovation (Huizing, 2011).

To our knowledge, this is among the first studies on open innovation to encompass large, medium and small manufacturing firms from European countries with different levels of technological development (see also, Cricelli et al., 2016 and Bengtsson et al., 2013, Revilla et al., 2016). Moreover, it is also one of the first articles to use large data sets to study open innovation in Portugal and Bulgaria. This paper complements previous empirical research on open innovation and external context, which up to now has focused mainly on the effects of industry (Keupp and Gassman, 2009; Liechtenthaler and Ernst, 2009), technological aggressiveness (Poot et al., 2009, Reed et al., 2012), competitive intensity (Lichtenthaler, 2008, Sandulli et al. 2012) and appropriability conditions (West, 2006). Additional external factors studied in the literature are technological intensity and knowledge leveraging, among others (Gassman, 2006).

The country effect of open innovation is important for policy design. In the European Union, innovation policies co-exist at several levels: European, national and regional (Balaz et al., 2005; García Manjón, 2010) and while efforts are expended to coordinate these policies, the Union also recognises the need to take countries' idiosyncrasies such as infrastructures, level of investment and general level of education and so on into account in the design of policies promoting innovation (European Commission, 2011; Izsak et al., 2015). Similarly, in the case of open innovation, various European Union initiatives that seek to promote open innovation state the need to take individual country characteristics into consideration (European Commission, 2016). This article may also be of interest to managers of firms with operations in multiple countries with various levels of technological development.

The remainder of the article is structured as follows. The next section presents an overview of the literature and puts forward the hypotheses that guided the research. This is followed by a methodological section that discusses the chosen research method. The results are presented next, followed by a section in which the findings are discussed. Implications for theory and practice are proposed in the concluding section, in addition to the limitations of the study and suggestions for future research.

2. Literature review

2.1. The degree of openness

More than a decade ago, Chesbrough (2003) proposed open innovation as a new paradigm, which rapidly gained the acceptance of scholars and was widely implemented by practitioners.

In contrast to the dichotomy model of closed versus open innovation proposed in some articles, a large part of the literature considers how open innovation can be adopted to different degrees (Dahlander and Gann, 2010, Gassman and Enkel, 2004; Hochleitner et al., 2017; Laursen and Salter, 2006; Lanzarotti and Manzini, 2009; Verganti and Pisano, 2008).

There have been different attempts to characterise the degree of openness. For instance, Laursen and Salter (2006) define the concepts of breadth (number of different search channels) and depth (intensity of use of sources of innovative ideas) of open innovation activities and Keupp and Gassman (2009) identify four archetypes of firms, which are classified according to the breadth and depth of their open innovation. Verganti and Pisano (2008) propose a model that relates hierarchical organizational levels with degree of openness and Lazzarotti and Manzinni (2009) introduce the number and type of partners and the type of phases of the innovation process that are open as measures of the firm's degree of openness. Moreover, Gassman and Enkel (2004) consider inbound, outbound and coupled activities, whereas Dahlander and Gann (2010) use the dimensions of inbound versus outbound open innovation activities and pecuniary versus non-pecuniary interactions.

This article adopts a measure of the firm's degree of openness that distinguishes between firms for which innovation remains essentially an internal matter and firms that have embraced the open innovation paradigm, a distinction based on the direct answers given by the firms' managers in the CIS questionnaire. Although this approach results in a dichotomic valuation, the phrasing of the questionnaire on which it is based acknowledges that the boundary between open and closed

innovation is blurred and that the degree of openness is in fact a continuum. The limitations of this approach are discussed later in the paper.

While the positive implications of open innovation seem to prevail, its alleged benefits - such as accelerating internal innovation and expanding the markets for external use of innovation (Chesbrough, 2006) - have not gone unquestioned. Part of the literature has also highlighted the disadvantages that open innovation can have, such as more complex innovation processes that result in higher managerial costs, the 'not invented here' syndrome, unwanted spillovers and other effects that lower firms' competitive advantage (Cheng and Shiu, 2015; Lazzarotti and Manzini, 2009; Raasch et al., 2009; Reed et al. 2012; van de Vrande et al., 2009; West, 2006).

Recognising both the benefits and costs of open innovation, the optimal degree of openness for a given firm would result from a balance between the positive and negative effects of open innovation in a given context that is characterised by internal and external factors (Reed et al., 2012, Sandulli et al., 2012; West, 2006). The context effects are discussed in the next sections.

2.2. . Context effects

The context effects of open innovation have been studied in relation to several of firms' external and internal factors. In this study, we focus on the country effect as a contingency that can affect firms' optimal choices in terms of the degree of openness.

Among the external context effects that have been studied, the most widely analysed is the effect of industry (Keupp and Gassman, 2009; Liechtenthaler and Ernst, 2009). As a matter of fact, open innovation was initially proposed based on evidence from a handful of large high-tech companies (Chesbrough, 2006) and from there it extended to other sectors, which were not necessarily high-tech industries (Dahlander and Gann, 2010). Other context effects considered have been technological aggressiveness (Poot et al., 2009, Reed et al., 2012), technological intensity and knowledge leveraging (Gassman, 2006), competitive intensity (Lichtenthaler, 2008, Sandulli et al. 2012) and the appropriability regime (West, 2006).

Country effects may encompass several of the context effects mentioned above. For instance, the appropriability regime varies with the type of knowledge (whether it can be protected by legal instruments and / or by strategic instruments, like time to market, secrecy and so on) in a given industry but also, in the case of multi-country studies, with how effective the enforcement of the rights on knowledge is in each country. Similarly, technological intensity and knowledge leveraging vary across industries (Gassman, 2006) as well across countries with different levels of technological development (by constructing the European Union Innovation Scoreboard index used in this study).

In a review, Gassmann et al. (2010) pointed to the need for further research on the degree of globalization of open innovation (the spatial perspective). These authors suggest that the uneven distribution of knowledge across territories may have hindered the shift in paradigm from closed to open innovation in less technologically developed economies. In this sense, it seems plausible that firms in more technologically developed countries where knowledge is more widespread may be able to benefit more from being open than their counterparts in less developed ones (Gasmann at al., 2010).

Geographically, the relevance of open innovation has been empirically shown for many firms in technologically developed economies, with most empirical work initially carried out with data on US firms, but later including large data studies from different European countries including the United Kingdom (Laursen and Salter, 2006), France (Simeth and Raffo, 2013), the Netherlands (Poot, T. et al., 2009, Raymond et al., 2006), Denmark (Tranekjer, T. and Knudsen, M., 2012), Spain (Barge-Gil, 2010), Belgium (Faems et al. 2010), Germany, Switzerland and Austria (Inauen and Schenker-Wicki, 2011), Italy (Lazzarotti et al., 2011), Finland and Sweden (Bengtsson et al., 2015). However, despite all this evidence, there are still few studies on open innovation in less technologically developed European economies. Moreover, some multi-country studies that include data from less technologically developed economies do not control for country effects (Cricelli et al., 2015).

This article characterises open innovation in European countries with different levels of technological development. The use of homogeneous CIS data allows for a comparison of open innovation across the three countries studied.

2.3. Innovation activities

Both product and process innovations are included in the analysis. Product innovations are traditionally related to market demand, through providing new products or entering new markets, whereas process innovations are normally related to the supply side of the market and are aimed at lowering costs or reducing production or delivery time (Martinez-Ros, 2000). The information on process innovations is normally less visible to other firms than the information on product innovations. Up to now, most open innovation articles have predominantly focused on product innovations, with some exceptions (see for instance West and Gallagher, 2006). Including process innovations in our analysis contributes to bridging this gap. Given their different nature, one cannot assume *a priori* that the relationship between the openness of the firm and either type of innovation will be the same in a variety of contexts (Baldwin, Hanel and Sabourin, 2002; Cohen and Keppler, 1996, Damanpour, 2010). Hence, this article analyses product and process innovation data separately.

2.3.1. Innovativeness

This section begins by distinguishing between firms that introduced innovative products and/or processes into the market during the study period and firms that did not. We focus on the first group. According to Chesbrough (2006), openness can enhance a firms' ability to both innovate and to appropriate the benefits of innovation. Building upon this idea, it seems intuitive that there will be a positive relationship between the innovativeness of a particular firm and the degree of openness in the development of its innovations. Despite most of the empirical literature having found evidence to support this assumption (see, for instance, Bae and Chang, 2012; Barge-Gil, 2013, Nieto and Santamaria, 2007, Parida et al., 2012, Spithoven et al. 2010), some studies (for instance, Laursen and Salter, 2006) have found a negative relationship between open innovation activities and innovation outcomes. In line with the most frequent results, the following hypotheses are put forward:

Hypotheses 1

1a. Manufacturing firms that introduce more innovative products into the market are more likely to have a higher degree of openness in the development of their products

1b. Manufacturing firms that implement more innovative processes are more likely to have a higher degree of openness in the development of their processes

2.3.2. Innovation strategy

Open innovation can contribute to innovation in general through easing the availability of information and its diffusion. The benefits and costs of these events might affect firms differently depending on their innovation strategies (Badawy, 2011, Gassmann, 2006, Keupp and Gassmann, 2009).

This article distinguishes between firms that develop 'new-to-market' innovations and firms that only develop innovations that are 'new to the firm'. According to the OECD (2015), 'new-to-market' product innovation refers to the introduction of a new or significantly improved product into the firm's market before any other competitors (the product may have already been available in other markets).

Being first in a market can bring competitive advantage through patents obtained, being able to influence consumer preferences and being ahead of the competitors. On the other hand, imitators can save on research and development resources, as well as be able to compete more efficiently through improving the product launched by the market leader (Lieberman and Asaba, 2006). A broad range of articles from diverse approaches that study the incentives for invention versus imitation examine under which market conditions imitation can spur rather that dampen innovation. The

degree of market competitiveness, the appropriation regime and the economic rents to be extracted from the consumer are among the relevant elements influencing the result.

While the increased flow of information and knowledge between firms that characterises open innovation eases imitation, the final effects of this increased flow of information on the introduction of innovations that are 'new- to-market' is unclear. Several studies have examined some of the arguments above in the context of open innovation (Cappelli et al., 2015, Cheng and Shiu, 2015; Hochleitner et al., 2017; Reed et al., 2012; Sandulli et al., 2012).

Capelli et al. (2014) find that in an open innovation context some spillovers ease imitation while others enhance innovation. Cheng and Shui (2015) find that inbound open innovation activities (which are the ones mostly captured by CIS data) enhance radical innovation performance but hinder incremental innovation performance. In a recent paper, Hochleitner et al. (2017) distinguish between product innovators (in the sense of inventors or world-first innovators) and imitators and find that open innovation activities can be advantageous for both world-first innovators and imitators. The article finds that open innovation can be advantageous not only for imitative innovation, but also for introducing world-first innovations. On the other hand, Reed et al. (2012) explore how open innovation may affect a firm with differentiation-based competitive advantage. The article finds that economic rents from property rights (which can be positively related to 'new to market' products) can be lost in an open innovation context, while the rents from experience-curve effects, differentiation, distribution and switching costs are not.

While the recent evidence on the effects of open innovation in the development of 'new to market' products is mixed, we will favour the view that open innovation helps firms to create and commercialize innovations (West et al., 2014). Accordingly, we put forward the following hypotheses for both new-to-market products and process innovations:

Hypotheses 2

2a. Manufacturing firms that introduce more innovative products that are 'new-to-market' are more likely to have higher degree of openness in the development of their products

2b. Manufacturing firms that implement more innovative processes that are 'new-to-market' are more likely to have a higher degree of openness in the development of their processes

3. Methodology

3.1. Data

The data used for this study comes from the Community Innovation Survey (CIS), which is a harmonised survey in 22 European countries. This article uses data from the CIS 2008 edition, which collected information about product and process innovation, organisational and marketing innovation and other key variables for the three-year period 2006 to 2008.

Three countries were selected to test the above hypotheses. The criteria for selecting the countries were (i) availability of data and (ii) country differentiation. We excluded the countries which were missing some of the variables used in this study and, because innovation activity differs widely across countries and economic sectors (Parvan, 2009), we chose to analyse countries with different levels of innovation development. We based our selection on 'The EU Summary Innovation Index' (SII, 2008), which includes Germany (with an 'innovation index well above the EU-27 average') in the group of 'innovation leaders', Portugal (with an innovation index 'below that of the EU average') in the group of 'moderate innovators and Bulgaria (with index scores 'significantly below the EU-27 average, but moving towards the average over time') in the fourth quartile of countries that are 'catching up'.

3.2. Measures

3.2.1. Dependent variable: degree of openness

There is no consensus in the literature on measuring the degree of openness of a firm. Indeed, various reviews (see for instance West et al., 2014) suggest the need for further research on this aspect.

The surge in empirical studies on open innovation using large data sets has brought about new 'proxies' for measuring the degree of openness of a firm including the range ('breadth') and intensity ('depth') of a firm's open innovation practices (for instance, Laursen and Salter, 2005, 2014, Cruz-González et al., 2015, Keupp and Gassmann, 2009), the use of external sources and collaborations (for instance, Faems et al. 2010, Parida et al., 2012, Van de Vrande et al.,2009) and traces of patent data (for instance, Kim et al., 2016) to learn about firms' knowledge flows. This article chooses to follow Barge-Gil (2010, 2013) and uses the answers to question 2.2 of the questionnaire for product (good or service) innovation and to question 3.2. for process innovation. In both cases the question is, 'Who developed these product/process innovations?' and there are three possible answers: (i) 'mainly your enterprise or enterprise group'; (ii) 'mainly your enterprise together with other enterprises or institutions' and (iii) 'mainly other enterprises or institutions'. Only one answer is permitted.

To test our hypotheses, we have transformed the three ordinal degrees of openness into a dichotomous variable where 0 means 'closed innovation' and 1 means 'some degree of openness'. In

our view, this variable captures the concept of 'openness' more accurately than other proxies. Table 1 presents the descriptive analysis of the degree of openness by country with regards to the selected proxy. For both product and process innovation, the results show that the Bulgarian manufacturing firms are the most closed (79.8% and 72.1% respectively). On the other hand, if we take 'some degree of openness' (by amalgamating the 'in cooperation' and 'mainly other enterprises' answers into a single category) into consideration, it can be observed that the German manufacturing firms are the most open for both product and process innovation (24.1% and 44% respectively).

(Table 1)

3.2.2. Independent variables: product/process innovations and new to the market

To account for innovativeness, this article uses the answers to question 2.1, which asked 'During the three years 2006 to 2008, did your enterprise introduce?'. Two product innovation typology options were offered: 'new or significantly improved goods' and 'new or significantly improved services'. With regards to process innovation, this article uses the answers to question 3.2, which asked 'During the three years 2006 to 2008, did your enterprise introduce…?'. In this case, three different process innovation typologies were offered: improved methods of manufacturing or producing goods or services; improved logistics, delivery or distribution methods for your inputs, goods or services; and improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting or computing.

Table 2 presents the frequencies and percentages of the number of product and process innovations introduced by country. With regards to product innovation, it can be observed that the introduction of 'new or significantly improved goods' is much more frequent than the introduction of 'new or significantly improved services'. By country, Germany introduces more 'new or significantly improved goods' and Portugal introduces more 'new or significantly improved services.'

Similarly, the introduction of one type of process innovation (improved methods of manufacturing or producing goods or services) is also much more frequent than the rest. Portugal is the country with the highest introduction of process innovations of any type, with Germany following close behind.

(Table 2)

The measure for 'new- to-market' comes from two CIS questions. With regards to product innovation, this article uses the answers to question 2.3, which asked 'Were any of your product innovations during the three years 2006 to 2008 within the category new to the market?' With regards to process innovation, three options were offered to answer question 3.3, which asked 'Were any of your process innovations introduced between 2006 and 2008 new to your market?': 'Yes', 'No' and 'Do not know'. Table 3 presents the frequencies and percentages of product and process innovations introduced that were new to the market during the period 2006-2008.

(Table 3)

3.2.3. Control variables: size and belonging to a group

The CIS questionnaire provides the opportunity to control for the potential impact of some firm-specific characteristics on the degree of openness. Two control variables, size and belonging to a group, were introduced into the model. To measure size, this paper uses the answers to question 11.2, which asked 'What was your enterprise's total number of employees in 2006 and 2008?' For the purposes of this study, only the data from 2008 was used. To assess whether the firm belongs to a group, this paper uses the answers to question 1.1, which asked 'In 2008, was your enterprise part of an enterprise group?' The descriptive analysis is shown in Table 4.

In terms of size, Bulgaria and Portugal are similar in the sense of having a large percentage of small firms, while Germany has a more balanced percentage of firms across the three categories.
Similar patterns are observed for 'belonging to a group'. Bulgaria and Portugal are alike with over 80% of their firms not belonging to a group, whereas Germany has a more balanced sample of independent firms and firms belonging to a group.

(Table 4)

4. Results

Logistic regression analysis is used to contrast the hypotheses previously raised. Mention et al. (2011) explain how this is an often-used method to investigate the relationship between discrete responses and a set of explanatory variables. The same authors also list various references that discuss the validity of the technique (e.g. Agresti, 1990; Collett, 1991; Cox and Snell, 1989; Hosmer and Lemeshow, 2000; Stokes et al., 2000).

All the variables in the full models are treated as dichotomous variables, except for the control variable SIZE, which is transformed from an ordinal of three categories to a dummy variable (0: < 50 employees; 1: >=50 employees), as shown in table 4.

Table 5 summarises the definitions and measurements of the variables of our models. The full models are as follows:

- *Model A_n: Logit (OPEN_PROD) = b0 + b1 * INPDGD + b2 * INPDSV + b3 * NEWMKT + b4 * SIZE + b5 * GP*
- *Model B_n: Logit (OPEN_PROC) = b0 + b1 * INPSPD + b2 * INPSLG + b3 * INPSSU + b4 * INPSNM + b5 * SIZE + b6 * GP*

(Table 5)

Table 6 presents the results of the six regressions models performed. For each country, models A and B are contrasted by logistic regression analysis and the results obtained for each country are now discussed.

In the case of Germany, similar results are obtained for the models A_1 and B_1. In A_1 two independent variables are statistically significant with a negative sign, INPDGD and NEWMAKT. In B_1 there are also two significant independent variables, again with a negative sign, INPSPD and INPSNM. These results seem to indicate that the firms that are most innovative and also introduce more innovations that are new to the market are the ones with a lower degree of openness. Some differences between product and process innovations are observed in the control variables: SIZE is the only significant variable and is negative in the case of product innovation and GP is only significant and negative in the case of process innovation.

The results obtained for the two Portugal models are similar to those of the Germany model, with some differences. First, although in model A_2 the two countries have the same significant variables, the coefficients are lower. Also, the variables INPSPD and INPSNM have significant coefficients with the same sign as model B_1, but they have lower coefficients. Moreover, in model B_2 INPSLG and INPSSU are significant with a negative and positive sign, respectively. Finally, there are also differences in the control variables of models A_2 and B_2. In A_2 only GP is significant with a negative sign and in B_2 only SIZE is significant with a positive sign.

In contrast with the Germany and Portugal models, most of the significant variables for Bulgaria have positive coefficients (INPDSV and NEWMKT in model A_3 and INPSNM in model B_3). Only the variable INPSSU has a negative sign and then with a low significance ($p<0.1$). These results would suggest that the more innovative the Bulgarian manufacturing firms are and the greater the number of these innovations that are new to the market, the higher the probability of the firms being more 'open'. In the case of Bulgaria, the variable SIZE is significant only in model B_3. GP is not significant in either model.

(Table 6)

5. Discussion of results

The results of our regression analysis show the validity of the contextual approach for both product and process innovations, for which this article runs separate regressions. With regards to product innovations, the sign of the relationship between the degree of innovativeness of a firm and the degree of openness of the economy is significant and negative for Germany and Portugal in the case of goods and significant and positive in Bulgaria in the case of services. Hence, hypothesis 1a is partially accepted for Bulgaria and rejected for Germany and Portugal. Therefore, there are clear country divergences.

In the case of hypothesis 1b, the relationship is significant and negative for Germany and Portugal in the case of improved methods of manufacturing. In the case of improved logistics, delivery or distribution methods, the relationship is significant but negative for Portugal. Finally, in the case of supporting activities, which was found to be the less extended process innovation, it is positive and significant for Portugal and negative and significant for Bulgaria. Hence, hypothesis 1b is mostly rejected. Here as well, the results differ between countries.

In the case of hypothesis 2a, the results for Germany and Portugal are significant but negative and significant and positive for Bulgaria. Hence, hypothesis 2a is partially accepted. The significance and signs of the relationships tested in hypothesis 2b are the same as for hypothesis 2a. Again, there are sign divergences between countries.

These results suggest that the relationship between the choice of the degree of openness and the innovativeness and innovation strategy of firms may well depend on the level of technological development of the environment in which the firm operates. On the other hand, there seems to be

no clear pattern in the relationship between either the size of a firm and whether this firm belongs to a group and its degree of openness.

6. Conclusions

This article constitutes a first approach to a European cross-country comparison of open innovation, a surprisingly little-explored field given the surge of articles on this topic in recent years. Moreover, the proliferation of studies that have found empirical evidence of open innovation practices in firms in Western economies has not been accompanied by a similar abundance of research evidence of the same in firms in less developed economies. Recent reviews have stressed the need to take context dependencies into consideration. In this regard, this paper takes the fact that the degree of technological development of an economy is a relevant factor into consideration.

First, the article examines the relation between the degree of openness of a firm and its innovativeness in terms of the number of positive answers to the introduction of product and the implementation of process innovations. Second, it relates a firm's degree of openness with its innovation strategy. It also controls for the effect of size and belonging to a group.

With regards to the relationship between innovativeness and the degree of openness of firms, the signs of the regressions confirm that there are differences between the three countries: the sign is negative in the cases of Germany and Portugal and positive in the case of Bulgaria.

With regards to innovation strategies, the results of the analysis show that there are country differences in the relationship between introducing products or processes that are 'new-to-market' and the degree of openness of firms.

The results obtained suggest that the country contingency factor should be taken into consideration in multi-country studies covering countries with different levels of technological development.

This approach at a multi-national level may uncover other external contingency effects that the literature has examined at a national and / or industry level (appropriability regime, technological intensity and so on). For instance, in choosing the degree of openness, factors like market structure or the potential rents from customers might be more relevant than the availability of knowledge, which is more pertinent to developed economies.

The results of this study are relevant for academics as they show the need to control for country characteristics in the study of open innovation. Managers may also like to take this paper into account,

as it shows how different innovation strategies can have different consequences depending on the level of technological development of the country in question. Finally, this study is potentially interesting for policy makers as it stresses the need to at least partially customise the initiatives aimed at promoting open innovation.

The limitations of this study are two-fold. The first obvious limitation is that the validity of its results applies only to the set of data from the countries studied; problems with the comparability of the data (responses to some questions were not available for all countries and/or were tabulated differently) prevented us from including more countries in the analysis. In this respect, further studies that compare open innovation across countries with differing degrees of technological development are needed. Second, it may be interesting to include more years in the study to learn about the evolution of the openness of innovation strategies. Again, in this regard we encountered some difficulties, which were related to changes in the questionnaire over the intended period of study.

More research is needed using data that allows for the control of more external contingency factors to be able to compare the results with those of this article. Additionally, it may be interesting to compare our approach to measuring the degree of openness of a firm's innovation activities with previously published approaches like breadth and depth (i.e., Laursen and Salter, 2005, 2014, Cruz-González et al., 2015, Keupp and Gassmann, 2009), while controlling for country dependency. These tests may contribute to validating the various measures, which could then be used to analyse the openness of innovation in countries with data missing for some variables.

Bibliography

Agresti, A. (1990), *Categorical Data Analysis,* John Wiley & Sons, Inc, New York, NY.

Badawy, M. (2011) "Is open innovation a field of study or a communication barrier to theory development? A perspective", *Technovation*, Vol. 31 No. 1, pp. 65-67.

Bae, Y., and Chang, H. (2012), "Efficiency and effectiveness between open and closed innovation: empirical evidence in South Korean manufacturers", *Technology Analysis & Strategic* Management, Vol. 24 No. 10, pp. 967-980.

Balaz, V., Kluvankova, T. and Zajac, S. (2005) Conceptual Economic Issues of Regional Innovations, Institute for Forecasting. Slovak Academy of Science, Bratislava.Barge-Gil, A. (2010), "Open, Semi-open and Closed Innovators: Towards an explanation of Degree of Openness", *Industry and Innovation*, Vol. 17 No. 6, pp. 577-607.

Baldwin, J., Hanel, P. and Sabourin, D. (2002) "Determinants of innovative activity in Canadian manufacturing firms", in: Kleinknecht, A. and Mohnen, P. (Eds.), *Innovation and Firm Performance*, Palgrave, New York, pp. 86-111.

Barge-Gil, A. (2013), "Open strategies and innovation performance", *Industry and Innovation* Vol. 20 No. 7, pp. 585-610.

Cappelli, R., D. Czarnitzki, D., and Kraft, K. (2014) "Sources of spillovers for imitation and innovation", *Research Policy*, Vol. 42, No. 1, pp. 115-120

Chandler, A. (1990), *Scale and Scope: The Dynamics of Industrial Capitalism,* Harvard University Press, Cambridge, MA.

Chesbrough, H. (2003), *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Harvard University Press, Cambridge, MA.

Chesbrough, H. (2006), "Open innovation: a new paradigm for understanding industrial innovation", in: Chesbrough, H., Vanheverbeke, W. and West, J. (Eds.), *Open Innovation: Researching a New Paradigm*, Oxford University Press, Oxford, pp. 1-12.

Chesbrough, H. and Crowther, A.K. (2006), "Beyond high tech: early adopters of open innovation in other industries", *R&D Management*, Vol. 36 No. 3, pp. 229-236..

Christensen, J.F., Olesen, M.H. and Kjaer, J.S. (2005), "The industrial dynamics of open innovation-evidence from the transformation of consumer electronics", *Research Policy*, Vol. 34 No. 10, pp. 1533-1549.

Cohen, W. and Klepper, S. (1996), "Size and the nature of innovation within industries: the case of process and product R&D", *Review of Economics and Statistics*, Vol. 78, No. XXX, pp. 232-243.

Collet, D. (1991), *Modeling Binary Data*, Chapman and Hall, London.

Cox, D.R. and Snell, E.J. (1989), *The Analysis of Binary Data*, Chapman and Hall, London.

Cricelli, L., Greco, M. and Grimaldi, M. (2016), "Assessing the open innovation trends by means of the Eurostat Community Innovation survey", *International Journal of Innovation Management*, Vol. 20 No.3, DOI: 10.1142/S1363919616500390.

Cruz-González, J., López-Sáez, P., Navas-López, J.E. and Delgado-Verde, M. (2015), "Open search strategies and firm performance: The different moderating role of technological environmental dynamism", *Technovation*, Vol. 35, pp. 32-45.

Dahlander, L. and Gann, D. (2010), "How open is innovation", *Research Policy*, Vol. 39 No. 6, pp. 699-709.

Damanpour, F. (2010), "An Integration of Research Findings of Effects of Firm Size and Market Competition on Product and Process Innovations", *British Journal of Management*, Vol. 21 No.4, pp. 996-1010.

European Commission (2011) Innovation Union Scoreboard 2010, European Commission, Brussels.

European Commission (2016) Open Innovation 2.0, European Commission, Luxembourg.

European Union (2008), *European Union Scoreboard. Summary Innovation Index,* European Commission, Brussels.

Faems, D., De Visser, M., Andries, P. and Van Looy, B. (2010), "Technology alliance portfolios and financial performance: Value-enhancing and cost-increasing effects of open innovation", *Journal of Product Innovation Management*, Vol. 27, No.6, pp. 785-796.

García Manjón, J. (2010), "A proposal of indicators and policy framework for innovation benchmark in Europe", *Journal of Technology Management & Innovation*, Vol. 5, No. 2, pp.13-23.

Gassmann, O. (2006), "Opening up the innovation process: towards an agenda". *R&D Management*, Vol. 36, No. 3, pp. 223-228.

Gassmann, O. and Enkel, E. (2004), "Towards a Theory of Open Innovation: Three Core Process Archetypes. In: R&D Management Conference, Lisbon.

Gassmann,O., Enkel, E., Chesbrough, H. (2010), "The future of open innovation". *R&D Management*, Vol. 40, No. 3, 213-221.

Hochleitner, F.P., Arbussà, A. and Coenders, G. (2017) 'Inbound open innovation in SMEs: indicators, non-financial outcomes and entry-timing', Technology Analysis & Strategic Management, Vol. 29, No. 2, pp.204-218.

Hosmer, D.W, Jr. and Lemeshow, S. (2000), *Applied Logistic Regression,* John Wiley & Sons, Inc., New York.

Huizing, E. (2011), "Open innovation: State of the art and future perspectives", *Technovation*, 31, pp. 2-9.

Inauen, M. and Schenker-Wicki, A. (2011), “The impact of outside-in open innovation on innovation performance”, *European Journal of Innovation Management*, Vol. 14 No. 4, pp. 496-520.

Keupp, M. and Gassmann, O. (2009), “Determinants and archetype users of open innovation”, *R&D Management*, Vol. 39 No. 4, pp. 331-341.

Kim, s, Kim, H. and Kim, E. (2016), “How knowledge flow affects Korean ICT manufacturing firm performance: a focus on open innovation strategy”, *Technology Analysis & Strategic Management*, Vol. 28 No. 10, pp. 1167-1181.

Kirschbaum, R. (2005), “Open innovation in practice”, *Research Technology Management*, Vol. 48 No. 4, pp. 24-28.

Lamoreaux, N, D Raff, and Temin, P. (1999), *Learning by doing in markets, firms, and countries,* University of Chicago Press, Chicago, IL.

Laursen, K., Salter, A.J. (2004), “Searching high and low: what type of firms use universities as a source of innovation?”, Research Policy, Vol. 33, No 8, pp. 1201–1215

Laursen, K. and Salter, A. (2006), “Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms”, *Strategic Management Journal*, Vol. 27 No.2, pp. 131-150.

Lazzarotti, V. and Manzini, R. (2009) “Different modes of open innovation: A theoretical framework and an empirical study”, International Journal of Innovation Management, Vol. 13, No. XXX, pp. 615XXXX

Lazzarotti, V., Manzini, R. and Pellegrini, L. (2011), “Firm-specific factors and the openness degree: A survey of Italian firms”, *European Journal of Innovation Management*, Vol. 14 No.4, pp. 412-434.

Lee, S., Park, G., Yoon, B. and Park, J. (2010), “Open innovation in SMEs—An intermediated network model”, *Research Policy*, Vol. 39 No.2, pp. 290-300.

Lichtenthaler, U. (2008), “Open innovation in practice: an analysis of strategic approaches to technology transactions”, *IEEE Transactions on Engineering Management*, Vol. 55 No. 1, pp. 148-157.

Lichtenthaler, U. and Ernst, H. (2009), “Opening up the innovation process: the role of technology aggressiveness”, *R&D Management*, Vol. 39 No.1, pp. 38-54.

Lieberman, M. and Asaba, S. (2006), “Why do firms imitate each other?”, *Academy of Management Review*, Vol. 31, No. 2, pp. 366-385

Lerner, J. (2000), “150 years of patent protection”, Working paper N.7478, National Bureau of Economic Research, Cambridge, MA.

Manzini, R., Lazzarotti, V., Pellegrini, L. (2016), "How to Remain as Closed as Possible in the Open Innovation Era: The Case of Lindt & Sprüngli", Long Range Planning, ARTICLE IN PRESS

Martinez-Ros, E. (2000), "Explaining the decisions to carry out product and processes innovations: The Spanish case", *Journal of High Technology Management Research*, Vol. 10, No. XXX, pp. 223-242.

Mention, A.L., Temel, S., Torkkeli, M. (2013), "Innovation and co-operation in emerging economies: two sides of the same coin", in *proceedings of the International Conference on Innovation and Entrepreneurship, in Amman, Jordania, 2013*, R.A. Kharabsheh (ed), The Hashemite University, Amman, Jordan.

Mowery, D. (2009), "Plus ca change: Industrial R&D in the "third industrial revolution" *Industrial and Corporate Change*, Vol. 18 No.1, pp. 1-50.

Mowery, D. (1983), "The relationship between intrafirm and contractual forms of industrial research in American manufacturing, 1900-1940", *Explorations in Economic History,* Vol. 20, pp. 351-74.

Nieto, M. J., and Santamaría, L. (2007), "The importance of diverse collaborative networks for the novelty of product innovation", *Technovation,* Vol. 27 No.6, pp. 367-377.

OECD (2015), "OECD Science, Technology and Industry Scoreboard 2015: Innovation for growth and society", OECD Publishing, Paris. http://dx.doi.org/10.1787/sti_scoreboard-2015-en

Parida, V., Westerberg, M. and Fishammar, J. (2012), "Inbound open innovation activities in high-tech SMEs: the impact on innovation performance", *Journal of Small Business Management*, Vol. 50 No.2, pp. 283-309.

Parvan, S. (2009), *Quality in the focus of innovation. Science and technology*. Eurostat: statistics in focus 33/2009, European Commission, Brussels.

Poot, T., Faems, D. and Vanhaverbeke, W. (2009), "Toward a dynamic perspective on open innovation: A longitudinal assessment of the adoption of internal and external innovation strategies in the Netherlands", *International Journal of Innovation Management*, Vol. 13 No. 2, pp. 177-200.

Raasch, C., Herstatt, C. and Balka, K (2009), "On the open design of tangible goods", R&D Management, Vol. 39, XXXX, pp.382-393

Raymond, W., Mohnen, P., Palm, F., and van der Loeff, S. (2006), "A classification of Dutch manufacturing based on a model of innovation", *De Economist*, Vol. 154 No. 1, pp. 85-105.

Reed, R., Storrud-Barnes, S. and Jessup, L. (2012), "How open innovation affects the drivers of competitive advantage: Trading the benefits of IP creation and ownership for free invention", *Management Decision*, Vol. 50 No. 1, pp. 58-73.

Revilla, E., Rodriguez-Prado, B. and Cui, Z. (2016) "A Knowledge-Based Framework of Innovation Strategy: The differential Effect of Knowledge Sources", *IEE Transactions on Engineering Management*, Vol. 63, No. 4, pp. 362-376

Sandulli, D., Fernandez-Menendez,J., Rodriguez-Duarte, A. and Lopez-Sanchez, J.I. (2012), "Testing the Schumpeterian hypotheses on an open innovation framework", *Management Decision*, Vol. 50 No.7, pp. 1222-1232.

Simeth. M. and Raffo, J. (2013), "What makes companies pursue an Open Science strategy?" *Research Policy*, Vol. 42 No. 9, pp. 1531-1543.

Spithoven, A., Frantzen, D., Clarysse, B. (ed.) (2010), "Heterogeneous firm-level effects of knowledge exchanges on product innovation: differences between dynamic and lagging product innovators", *Journal of Product Innovation Management,* Vol. 27 No.3, pp. 363-382.

Stokes, M.E., Davis, C.S. and Koch, G.G. (2000), *Categorical Data Analysis Using the SAS System,* Second Edition, SAS Institute Inc, Cary: NC.

Teece, D. (1986), "Profiting from technological innovation: implications for integration, collaboration, licensing and public policy", *Research Policy*, Vol. 15, pp. 285-305.

Tranekjer, T. and Knudsen, M. (2012), "The (unknown) providers to other firms new product developments: What's in it for them?", *Journal of Product Innovation Management*, Vol. 29 No. 6, pp. 986-999.

Van de Vrande, V., de Jong, J., Vanhaverbeke, W., and de Rochemont, M. (2009), "Open innovation in SMEs: Trends, motives and management challenges", *Technovation*, Vol. 29 No.6, pp. 423-437.

Verganti, R. and Pisano, G. (2008), "Which kind of collaboration is right for you*?", Harvard Business Review*, Vol. 86, No. 12, pp. XXX

West, J. (2006), "Does appropriability enable or retard open innovation?" in Chesbrough, H, Vanhaverbeke, W and West, J. (Eds.), *Open Innovation: Researching a new paradigm,* Oxford University Press, Oxford, pp.285-307.

West, J. and Bogers, M. (2015), "Leveraging External Sources of Innovation: A Review of Research on Open Innovation", *Journal of Product Innovation Management*, Vol. 31 No. 4, pp. 814-831.

West, J. and Gallagher, S. (2006), "Challenges of open innovation: the paradox of firm investment in open-source software", *R&D Management*, Vol.36 No.3, pp. 319–331.

West, J., Salter, A., Vanhaverbeke, W. and Chesbrough, H. (2014)," Open Innovation: The next decade", *Research Policy*, Vol. 43 No.5, pp. 805-811.

(Annex 1)

Table 1. Description of countries by degree of openness in product and process innovations

		Bulgaria		Germany		Portugal	
		n	**%**	**n**	**%**	**n**	**%**
mainly enterprise	*Product*	1,297	79.8%	1,047	75.8%	1,142	77.0%
	Process	1,189	72.1%	652	55.9%	1,121	64.1%
in cooperation	*Product*	172	10.6%	281	20.3%	270	18.2%
	Process	201	12.2%	391	33.5%	479	27.4%
mainly other enterprises	*Product*	156	9.6%	53	3.8%	71	4.8%
	Process	258	15.7%	123	10.5%	149	8.5%
Total	***Product***	**1,625**	**100%**	**1,381**	**100%**	**1,483**	**100%**
	Process	**1,648**	**100%**	**1,166**	**100%**	**1,749**	**100%**

Table 2. Description of countries by product and process innovation typology

		Bulgaria		Germany		Portugal	
		N	**%**	**N**	**%**	**n**	**%**
Product innovation:							
*New or significantly improved goods**	*No*	*7,553*	84.5%	1,527	54.1%	2,319	63.0%
	Yes	*1,389*	15.5%	1,297	45.9%	1,362	37.0%
	Total	***8,942***	**100%**	**2,824**	**100%**	**3,681**	**100%**
New or significantly improved services	*No*	*8,568*	95.8%	2,538	90.0%	2,908	79.0%
	Yes	*374*	4.2%	282	10.0%	773	21.0%
	Total	***8,942***	**100%**	**2,820**	**100%**	**3,681**	**100%**
Process innovation:							
New or significantly improved methods of manufacturing or producing goods or services	*No*	7,645	85.5%	1,916	65.5%	2,256	61.3%
	Yes	1,297	14.5%	1,010	34.5%	1,425	38.7%
	Total	**8,942**	**100%**	**2,926**	**100%**	**3,681**	**100%**
New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services	*No*	8,703	97.3%	2,494	85.2%	3,001	81.5%
	Yes	239	2.7%	432	14.8%	680	18.5%
	Total	**8,942**	**100%**	**2,926**	**100%**	**3,681**	**100%**
New or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting or computing	*No*	8,479	94.8%	2,389	81.6%	2,523	68.5%
	Yes	462	5.2%	537	18.4%	1,158	31.5%
	Total	**8,941**	**100%**	**2,926**	**100%**	**3,681**	**100%**

*exclude the simple resale of new goods purchased from other enterprises and changes of a solely aesthetic nature

Table 3. CIS description of countries by % of product and % of process innovations which are new to the market

		Bulgaria		Germany		Portugal	
		N	**%**	**n**	**%**	**N**	**%**
Product innovation:							
*New to the market**	*No*	964	59.3%	2139	67.6%	645	43.5%
	Yes	661	40.7%	1026	32.4%	838	56.5%
	Total	**1,625**	**100%**	**3,165**	**100%**	**1,483**	**100%**
Process innovation:							
	No	1127	82.1%	2185	88.3%	694	51.9%
	Yes	246	17.9%	290	11.7%	644	48.1%
	Don't know	0	0.0%	0	0.0%	0	0.0%
	Total	**1,373**	**100%**	**2,475**	**100%**	**1,338**	**100%**

* Your enterprise introduced a new or significantly improved good or service into your market before your competitors (it may have already been available in other markets)

Table 4. Description of countries by control variable (only manufacturing firms)

		Bulgaria		Germany		Portugal	
		n	%	N	N	%	N
Size:							
What was your enterprise's total number of employees in 2006 and 2008	*<50 employees*	6,456	72.2%	1,235	37.7%	2,368	64.3%
	50-249 empl.	2,142	24.0%	1,135	34.7%	1,071	29.1%
	>250 empl.	344	3.8%	905	27.6%	242	6.6%
	Total	**8,942**	**100%**	**3,275**	**100%**	**3,681**	**100%**
Belonging to a group*:							
In 2008, was your enterprise part of an enterprise group?	*No*	8,296	92.8%	1,828	55.8%	2,995	81.4%
	Yes	646	7.2%	1,447	44.2%	686	18.6%
	Total	**8,942**	**100%**	**3,275**	**100%**	**3681**	**100%**

* A group consists of two or more legally defined enterprises under common ownership. Each enterprise in the group can serve different markets, as with national or regional subsidiaries, or serve different product markets. The head office is also part of an enterprise group.

Table 5. Definition and measurement of variables

Variable	Definition and measurement
Dependent variables	
OPEN_PROD	1 if the firm has some degree of openness in product innovation 0 otherwise
OPEN_PROC	1 if the firm has some degree of openness in process innovation 0 otherwise
Independent variables	
INPDGD	1 if the firm has introduced new or significantly improved goods 0 otherwise
INPDSV	1 if the firm has introduced new or significantly improved services 0 otherwise
NEWMKT	1 if the firm has introduced new or significantly product innovations that are new to the market 0 otherwise
INPSPD	1 if the firm has introduced new or significantly improved methods of manufacturing or producing goods or services 0 otherwise
INPSLG	1 if the firm has introduced new or significantly improved logistics, delivery or distribution methods for inputs, goods or services 0 otherwise
INPSSU	1 if the firm has introduced new or significantly improved supporting activities in its processes, such as maintenance systems or operations for purchasing, accounting or computing 0 otherwise
INPSNM	1 if a firm has introduced new or significantly process innovations that are new to the market 0 otherwise
Control variables	
SIZE	1 if a firm has more than 50 employees 0 otherwise
GP	1 if a firm belongs to a group 0 otherwise

Table 6. Logit regression models

	Germany		Portugal		Bulgaria	
Dependent variable	OPEN_PROD	OPEN_PROC	OPEN_PROD	OPEN_PROC	OPEN_PROD	OPEN_PROC
Model	A_1	B_1	A_2	B_2	A_3	B_3
Independent variable						
INPDGD	-0.871*** (0.28)		-0.393*** (0.12)		0.358 (0.24)	
INPDSV	0.001 (0.22)		0.448*** (0.08)		0.844*** (0.19)	
NEWMKT	-0.368*** (0.13)		-0.248*** (0.07)		0.700*** (0.13)	
INPSPD		-0.487*** (0.22)		-0.310** (0.09)		-0.064 (0.21)
INPSLG		-0.257 (0.18)		-0.130* (0.07)		-0.028 (0.18)
INPSSU		0.210 (0.17)		1.049*** (0.08)		-0.336* (0.19)
INPSNM		-0.814*** (0.16)		-0.174** (0.07)		0.387** (0.15)
Control variables						
SIZE	-0.597*** (0.15)	0.285 (0.19)	-0.090 (0.09)	0.566*** (0.08)	0.062 (0.13)	0.395*** (0.12)
GP	-0.142 (0.15)	-0.502*** (0.17)	-0.280** (0.12)	0.063 (0.10)	0.082 (0.17)	-0.048 (0.17)
Log likelihood	1327.396	924.628	4258.232	4390.351	1577.618	1596.175
Nagelkerke R^2	0.062	0.096	0.032	0.095	0.054	0.022
N	1282	707	1483	1338	1625	1372

First category as a reference in all the dependent variables
Robust standard errors are reported in brackets under the logistic regression coefficients
****p<0.01; **p<0.05; *p<0.1*

Appendix A. CIS description of countries by economic activity

Nace coding	NACE Rev. 2	**BG**	**CY**	**CZ**	**DE**	**EE**	**ES**	**HU**	**IE**	**IT**	**LT**	**LV**	**NO**	**PT**	**RO**	**SI**	**SK**	**Total**	**%**
A	Agriculture, forestry and fishing	0	0	0	0	0	947	0	0	0	0	0	59	0	0	0	0	1006	0.79
B	Mining and quarrying	153	13	111	87	0	390	76	26	195	29	13	153	130	166	20	47	1609	1.26
C	Manufacturing	8942	430	2792	3275	2160	15979	2698	793	19709	880	393	1692	3681	5070	1327	824	70645	55.34
D	Electricity, gas, steam and air conditioning supply	104	1	176	161	114	116	121	5	0	55	31	118	33	144	27	103	1309	1.03
E	Water supply; sewerage, waste management and remediation activities	213	24	261	287	156	523	245	36	0	99	21	107	225	344	85	78	2704	2.12
F	Construction	0	0	453	0	0	2990	684	0	0	172	0	610	45	0	0	424	5378	4.21
G	Wholesale and retail trade	3555	286	672	203	354	5430	508	536	0	270	387	529	892	2142	455	421	16640	13.03
H	Transportation and storage	1543	114	391	409	452	2119	424	230	0	67	110	365	477	654	279	150	7784	6.10
I	Accommodation and food service activities	0	0	164	0	0	1371	0	0	0	0	0	0	0	0	0	0	1535	1.20
J	Information and communication	719	41	450	431	306	2150	234	180	0	200	55	566	348	454	155	98	6387	5.00
K	Financial and insurance activities	247	88	221	266	148	571	248	236	0	36	47	213	292	349	103	78	3143	2.46
L	Real estate activities	0	0	75	0	0	199	0	0	0	0	0	0	0	0	0	0	274	0.21
M	Professional, scientific and technical activities	383	27	562	576	266	2483	152	136	0	303	20	427	389	308	142	73	6247	4.89
N	Administrative and support service activities	0	0	476	321	30	2132	0	0	0	0	0	44	0	0	0	0	3003	2.35
	Total	15859	1024	6804	6016	3986	37400	5390	2178	19904	2111	1077	4883	6512	9631	2593	2296	127664	100.00
	%	12.42	0.80	5.33	4.71	3.12	29.30	4.22	1.71	15.59	1.65	0.84	3.82	5.10	7.54	2.03	1.80	100.00	