Firms' innovation objectives and knowledge acquisition strategies

1. Introduction

Innovation stems from knowledge; be it commercial, technological or organisational. Individual firms' internal stocks of knowledge are limited, however, emphasising the importance of acquiring external knowledge to enable effective innovation. Firms may of course decide not to innovate, or to innovate on the basis of proprietary knowledge developed purely within the firm. While this type of independent technological development strategy has been linked to the success of some groups of firms (Simon 1996), it is increasingly uncommon among innovative smaller firms (van de Vrande et al. 2009). Where a firm does decide to seek knowledge for innovation from outside the firm, it faces a number of choices relating to its knowledge acquisition strategy. What types of partner should it connect with (e.g. Brunetta, Marchegiani and Peruffo 2020; Dasí-Rodríguez and Pardo-del-Val 2015)? Which specific partners should be approached? How should these relationships be structured (Choi, 2020)? And, in the first instance, should the firm develop collaborative or interactive links with partners to jointly develop new knowledge? Or, should the firm simply access previously codified knowledge non-interactively, e.g. through imitation, copying or learning strategies (Glückler 2013)? The choice between interactive or non-interactive knowledge acquisition strategies is the focus of this article.

Antecedents of firms' knowledge acquisition strategies have been discussed elsewhere, with a focus on the influence of firms' internal capabilities and structure. Absorptive capacity, for example, typically measured using R&D and human capital measures, or firms' 'knowledge integration capability' (Wang, Chen and Fang 2018) has been shown to play a significant role in shaping firms' ability to take advantage of external knowledge (Spithoven, Clarysse, and Knockaert 2011; Moon 2011). Xia and Roper (2014) also identify a positive relationship between realised absorptive capacity and the extent of partnering activity, i.e. interactive knowledge acquisition, of small bio-technology firms. In a related study, Freel and Aslesen (2013) consider the role of organisational structure on firms' interactive partnering strategies, providing evidence that less hierarchic firms develop more diverse connections, i.e. engage more in interactive knowledge acquisition, and that team or project-based working may be particularly conducive to the development of deep or strong links between firms. A similar study by Moon (2011) links the breadth of firms' interactive knowledge search activities to their use of IP protection.

Existing research on the determinants of firms' knowledge acquisition strategies has four main limitations which we seek to address. First, existing studies tend to focus on firms' structural characteristics such as R&D, skills and organisational structures and their implications for external knowledge acquisition (Freel and Aslesen 2013; Mukherjee et al. 2013; Spithoven, Clarysse, and Knockaert 2011). There is little evidence to date on the strategies firms need to adopt in order to achieve both exploration and exploitation of knowledge (Xu and Cavusgil 2019). Here, following Moon (2011), we argue that firms' innovation objectives – or innovation strategies – may also be important in shaping firms' knowledge acquisition strategies. Second, existing studies focus predominantly on interactive knowledge acquisition through innovation partnering, paying little attention to the potential value of non-interactive knowledge sourcing mechanisms such as imitation or copying (Glückler 2013). Here, we seek to understand how firms' innovation objectives shape both interactive and non-interactive knowledge acquisition. Firms seeking to develop new-to-the-market innovation, for example, will need to develop new knowledge, a process which is most likely to involve interactive relationships, characterised by collaboration and mutual learning. Examples of such interactive knowledge acquisition would be collaborative R&D projects with universities or other firms. Firms seeking to develop new-to-the firm innovation – or imitations - on the other hand, may be able to acquire the knowledge needed through copying or reverse-engineering. Such non-interactive strategies emphasise the exploitation of pre-existing knowledge and are characterised by selfish, one-sided-learning. Hence combining the first two research issues, our overarching research question is, what is the effect of firms' knowledge acquisition strategies on firms' choice of interactive versus non-interactive knowledge acquisition strategies?

Thirdly, the extant literature provides little evidence as to sectoral differences, although the rationale for external knowledge search may differ significantly between sectors (Moon 2011). Finally, existing studies of knowledge search focus on a single country or region, although firms' ability to develop either interactive or non-interactive knowledge acquisition strategies will depend critically on the nature of the innovation eco-system within which they are operating. Therefore, here, we focus on the contrasting economies of Spain and the UK, with previous studies suggesting that firms may find it more difficult within the Spanish innovation system to access those collective resources which can support innovation. This may be particularly important where, like Spain, a country has an economic structure based largely on small firms which depend more strongly on externally acquired knowledge than larger firms (Royo 2007). Spanish companies also face a greater burden of regulation and legislation, a factor which has often been seen as having a potentially negative effect on innovative activity (Blind 2012; Epstein 2013; Ford, Steen, and Verreynne 2014; Kneller and Manderson 2012; Mazon et al. 2012; Michie and Sheehan 2003).

The remainder of the paper is organised as follows. Section 2 presents the conceptual framework and derives our hypotheses. Section 3 sets out the research context of the two different innovation eco-systems of Spain and the UK, and Section 4 describes the data and methods. Section 5 provides our estimation results, while Section 6 discusses these and concludes.

2. Conceptual framework and hypotheses

2.1 Defining firms' innovation objectives

Discussions of firms' innovation objectives typically reflect the diversity of firms' innovation activities, the relative risks and rewards of each type of innovation, and the need to balance resources and capabilities across different activities. A key distinction here is that between innovation-based and imitation-based strategies (Shenkar 2010; Schnaars 1994; Bolton 1993). Both may involve the introduction of new products or services to the market, with innovation-based strategies involving new-to-the-market innovations, while imitations are new products or services, which are new-to-the-firm but not new-to-the-market. Imitation may, of course, be of very different types ranging from licensed or unlicensed (counterfeit) copying of a product or service, through mimic products which copy some or all of the features of an innovative product or service, to products which emulate an existing product but may actually be better than the established market leader (Ulhoi 2012). Innovation-based and imitation-based strategies have very different risks and rewards and involve very different tactical choices, viz 'exploitative innovation strategies primarily build on improvements and refinements of current skills and processes and lead to incremental product changes … Exploratory innovation primarily involves the challenging of existing approaches … Outcomes of exploratory innovation strategies are superior new products with significant consumer benefits: they can enable the firm to enter or even create new markets' (Mueller, Rosenbusch, and Bausch 2013, p. 1607).

So, innovation may create first-mover advantages for the innovating firm. These may lead to higher returns from a desirable and unique product or service but may also have other advantages in terms of helping the first mover to learn rapidly about the markets and build brand loyalty among customers (Kopel and Loffler 2008)[1]. For imitators on the other hand the potential for 'second mover advantages' are also evident. Perhaps the key advantage for imitators is that the market leader has already taken much of the uncertainty out of the initial product or service introduction[2]. On the production side this may mean that the imitator can copy, emulate or reverse engineer the product design or service delivery of an innovator. On the demand side, the imitator can learn from the innovator about consumers' appetite for a particular product or service and what consumers are prepared to pay. The imitator's problem however is not always simple as they try to establish a position in a market share in which there is already at least one established player (Ulhoi 2012). Second mover advantages can certainly occur at a firm level and there is some evidence – particularly in less dynamic markets – that imitation may be a more profitable strategy than innovation (Lieberman and Asaba 2006). Imitation – second-mover – strategies may provide individual firms with a less risky option than innovation. At an industry and social level, however, imitation can have either positive or negative effects. On the positive side imitation may help to maximise the social and consumer benefits of the original innovation by making products or services available to more consumers. Imitation may also have negative effects, however, by reducing the variety of products or services within a market and increasing the collective vulnerability to external competition (Lieberman and Asaba 2006).

Innovation strategy may also involve process innovation objectives which can yield significant performance gains to the innovating firm (Rasiah, Gopal, and Sanjivee 2013). Strategies involving the adoption of advanced management techniques (AMTs), for example,

---

[1] A key issue for innovators in any marketplace, however, is their ability to sustain their position of market leadership. In some sectors – biotechnology or engineering – this may involve formal strategies such as patenting to protect intellectual property; in other sectors more strategic approaches may be adopted such as frequent changes or upgrades to product or service design. Aggressive pricing also provides a way in which market leaders may protect any first mover advantages (Ulhoi 2012).

[2] Imitation may also be a stepping stone towards innovation as firms build innovative capabilities. This process is perhaps clearest in developing economies where firms have steadily developed their R&D and creative competencies. On Korea see (Kim 1997), on Taiwan (Hobday 1995), on China (Lim and Kocaoglu 2011) and on Brazil, (Dorion, Pavoni, and Chalela 2008).

may enable firms to develop more flexible and adaptive production systems allowing smaller batch sizes and enabling firms to cope better with perceived environmental uncertainty (Hofmann and Orr 2005; Zammuto and Oconnor 1992), changes to regulation etc. More flexible production systems may also allow firms to adopt more complex innovation strategies with potentially higher returns (Hewitt-Dundas 2004). Process innovation may also facilitate more radical innovation strategies as firms seek to create market turbulence by engaging in disruptive innovation in order to establish a position of market or technological leadership (Anthony et al. 2008; Hang, Chen, and Subramian 2010).

2.2 Knowledge acquisition for innovation

There are two main mechanisms through which firms may seek to acquire knowledge for innovation[3]. First, firms may form deliberate, purposive connections with other firms or organisations as a means of interactively acquiring or accessing new knowledge. These might be partnerships, network linkages or contractually-based agreements entered into on either a formal or informal basis. This type of knowledge acquisition is characterised by strategic intent and mutual engagement of both parties, and may be characterised as a form of interactive learning (Glückler 2013). Second, firms might acquire knowledge deliberately but without the direct engagement of another party, i.e. non-interactively. Examples of this type of mechanism include imitation, reverse engineering or participation in network or knowledge dissemination events. Here, there is a clear strategic intent on the part of the focal firm but no mutuality in the learning process, and this may be characterised as non-interactive learning. For example, in their analysis of university-business connections, Hewitt-Dundas and Roper (2011) distinguish between knowledge connections 'characterised by a two-way flow of knowledge, e.g., through formal or informal joint ventures or collaborative R&D projects', and knowledge suppliers 'characterised by a more uni-directional transfer of knowledge'.

Interactive learning is initiated by firms' strategic decision to build interactive links and connections with other firms and economic actors (e.g., research institutes, universities and government departments) to capitalise on the knowledge of the linked parties, co-operate

[3] Firms may also acquire knowledge vicariously and unintentionally through informal spill-over mechanisms such as social contacts between employees and those in other firms, media publicity or demonstration effects, or through the mobility of labour between enterprises. These pure knowledge spill-overs represent un-priced gains to the firm, effectively increasing the social returns to knowledge (Beugelsdijck and Cornet 2001).

with the linked parties, and/or to exploit the knowledge together (Borgatti and Halgin 2011). Three characteristics seem important in measuring the potential benefits of interactive knowledge search that may enable an ensuing process of interactive learning: the number of connections the firm has; the mode of interaction adopted; and the nature of the embeddedness of the networks in which firms are involved (Borgatti and Halgin 2011; Glückler 2013).

At its simplest, interactive knowledge acquisition can be positively affected by a firms' number of connections. In purely statistical terms, since the payoff from any given innovation connection is unknown in advance, the chances of obtaining benefit from any connection in a given distribution of payoffs increases as the number of connections increases (Love et al, 2014). Having more connections increases the probability of obtaining useful external knowledge that can be combined with the firm's internal knowledge to produce innovation (Leiponen and Helfat 2010; Srinivasan et al. 2021). The extent or breadth of a firm's portfolio of external connections may also have significant network benefits, reducing the risk of "lock-in" where firms are either less open to knowledge from outside its own region (Boschma 2005), or where firms in a region are highly specialised in certain industries, which lowers their ability to keep up with new technology and market development (Camagni 1991). However, the capacity of management to pay attention to and cognitively process many sources of information is not infinite, since the span of attention of any individual is limited (Simon 1947). This attention issue means that while the returns to additional connections may at first be positive, eventually the firm will reach a point at which an additional connection actually serves to diminish the innovation returns of external networking (Laursen and Salter 2006; Leiponen and Helfat 2010; Srinivasan et al. 2021; Grimpe and Sofka 2009; Garriga, von Krogh, and Spaeth 2013).

Non-interactive knowledge acquisition is characterised by the absence of reciprocal knowledge and/or resource transfers between actors. The most frequently discussed modes of non-interactive knowledge acquisition are: imitation, where a firm absorbs the knowledge of other actors through observation of the actions/behaviour of the source actor; reverse engineering, where a firm derives knowledge from the final product of another firm, obtained from the market or through supply chain interaction; and the codification of knowledge, where a firm obtains knowledge through knowledge which is a public good such as news, patents and regulations etc. (Glückler 2013). As with interactive knowledge acquisition, the chances of obtaining useful knowledge from any non-interactive knowledge search will increase as the number of non-interactive search strategies or modes increases. Or, put another way, having more non-interactive knowledge acquisition strategies will increase the probability of obtaining useful external knowledge.

The contrasting nature of the knowledge acquisition processes developing from interactive and non-interactive knowledge search strategies, and consequent differences in the types of knowledge they generate, suggests the potential for a complementary relationship. Two groups of alternative explanations for this complementarity are possible relating to the contrasting functional contents of each type of search mode and/or their management and co-ordination. First, in terms of search content, it may be that the different types of knowledge acquisition processes - exploratory and exploitative – developing from interactive and non-interactive knowledge search strategies generate knowledge which plays a complementary role in firms' innovation activity. Interactive collaborations with universities or research centres, for example, may facilitate exploratory activity, while non-interactive search with customers or equipment suppliers may contribute more directly to exploitation (Faems et al. 2010; Lavie and Rosenkopf 2006). Second, there may be economies of scope as firms acquire knowledge about how to better manage and co-ordinate their external connections (Love, Roper, and Vahter 2014). This leads to our first hypothesis (see Figure 1):

> Hypothesis 1: Interactive and non-interactive knowledge search are complementary elements of firms' knowledge acquisition strategies.

2.3 Firms' innovation objectives and knowledge acquisition strategies

The knowledge necessary for successful innovation includes technical, commercial and market data, both codified and tacit. The types of knowledge needed will, however, depend significantly on the technological novelty, the focus of the innovation (i.e., product, service, process) and the stage of development of any innovation. Developing new-to-the-market innovations, for example, is likely to involve exploratory R&D activity and the development of new technological knowledge either by a firm itself or through external knowledge acquisition. Such interactive projects have a number of potential advantages – speed, risk sharing, access to a broader resource base – which can increase innovation quality and ameliorate both technological and commercial risk (Astebro and Michela 2005). Here, there is likely to be mutual learning as innovation partners interact to generate new knowledge. This suggests:

> Hypothesis 2: Knowledge acquisition through interactive relationships will be most important where firms' innovation objectives emphasise new product or service innovation.

Alternative knowledge acquisition strategies are non-interactive, involving mechanisms such as copying, imitation or the purchase of intellectual property through mechanisms such as licensing (Anand and Khanna 2000). In each case the emphasis is on the exploitation of existing knowledge. Such exploitative, non-interactive mechanisms may, however, allow firms to rapidly establish positions in new technical areas without undertaking a discovery process, and to avoid both the technological and commercial uncertainties implicit in such a process. A recent Korean study, for example, suggested that: 'technology acquisition may be one of the most efficient collaborative activities when this activity can be simply conducted to complement insufficient resources' (Suh and Kim 2012, p. 361). Ulhoi (2012) outlines the range of outcomes which may arise from non-interactive imitation strategies: Replica – licensed or unlicensed (counterfeit) copying of a product or service; Mimicry – copying some or all of the features of an innovative product or service; Analogue – developing a different product or service but with similar functionality. The implication is that:

> Hypothesis 3: Non-interactive knowledge acquisition will be most important where firms' innovation objectives emphasise product or service improvement.

Different types of innovation – product, process or service – will also require different types of knowledge (Roper, Du, and Love 2008). Knowledge search among customers, for example, might impact most strongly on product innovation (Su, Chen, and Sha 2007), while search with suppliers or external consultants might impact most directly on process change (Horn 2005; Smith and Tranfield 2005). The majority of process change is likely to be incremental and "firms frequently rely on machinery suppliers and outside consultants as sources of embodied process innovation, the challenges posed by change can draw on a variety of technical sources with different knowledge bases and aims" (Robertson, Casali, and Jacobson 2012, p. 822). Therefore we might argue that:

> Hypothesis 4: Non-interactive knowledge acquisition will be most important where firms' innovation objectives emphasise process innovation.

The innovation objective of reducing a firm's environmental impact is a rather generic one, which may encompass new as well as improved product development and process innovation. Overall, the pursuit of eco-innovation objectives poses significant challenges for firms, as eco-innovations often lie outside the firm's core competencies. They typically exhibit greater complexity, a systemic character, potential lack of fit with traditional innovation activities, greater technological and market uncertainty, and as such demand a shift in organizational goals, practices and routines (e.g. De Marchi 2012; Horbach et al. 2013). This may be particularly the case where reducing environmental impact involves exploratory R&D activities related to new product development. Collaborative partnerships will bring important access to a broader (knowledge) resource base. Indeed, evidence suggests that environmental innovators cooperate with external partners to a higher extent than other innovative firms (inter alia, De Marchi 2012; Cainelli, De Marchi and Grandinetti 2015; Jové-Llopis and Segarra-Blasco, 2018). This suggests:

> Hypothesis 5a: Interactive knowledge acquisition will be of significant, positive importance where firms' innovation objectives emphasise the reduction of environmental damage.

However, much innovative activity in the pursuit of the innovation strategy to reduce the firm's environmental impact involves either process innovation or incremental innovation. For example, strategies to reduce the amount of energy or materials used per unit produced capture efficiency-focused eco-innovation strategies related to, for instance, the adoption of cleaner production process technologies (Frondel, Horbach and Rennings 2007). Eco-product strategies (Ambec and Lanoie 2008) to replace outdated products or improve existing products' eco-friendliness may involve incremental innovation. Therefore we also argue that (Figure 1):

> Hypothesis 5b: Non-interactive knowledge acquisition will be of significant, positive importance where firms' innovation objectives emphasise the reduction of environmental damage.

3. Research context: Spain and the UK

Although both were within the EU during the period covered by our data, the UK and Spain have contrasting institutional and policy structures which may shape firms' innovation objectives and knowledge acquisition strategies. Hall and Soskice (2001), for example, develop the notion of comparative institutional advantage suggesting that in different countries 'institutions set the rules of the game, determine the capacity of co-ordination among businesses and, consequently their competitive advantage in world markets … Differences across countries in the quality and configuration of these institutional frameworks help explain disparities in firms' behaviour and performance' (Royo 2007, p. 48). Previous studies of innovation in the two countries have emphasised: (a) the stronger public sector influence on the innovation system in Spain; and, (b) the more complex regulatory environment for innovation in Spain (Mate-Sanchez-Val and Harris, 2014).

In terms of public sector influence on the innovation system, businesses account for a larger proportion of R&D spend in the UK than Spain, and government spend is proportionately less important in the UK. Higher education accounts for around a quarter of all R&D spend in both countries (Table 1, part a). In terms of the funding of R&D, government is a more significant funder of R&D in Spain both in terms of total R&D and that R&D undertaken by firms (Table 1, part B). The relative importance of public R&D support and international funding is reflected in the findings of Mate-Sanchez-Val and Harris (2014) whose empirical analysis suggests that 'in Spain, public support is more important in promoting innovation activities; whereas linkages with international markets are more important for companies in the UK' (p. 452) (see also Roper et al. 2007). The second key difference between the Spanish and UK innovation systems is that the burden of regulation and legislation is greater for Spanish companies, a factor which has often been seen as having a potentially negative effect on innovative activity (Blind 2012; Epstein 2013; Ford, Steen, and Verreynne 2014; Kneller and Manderson 2012; Mazon et al. 2012; Michie and Sheehan 2003). Evidence on the impact of regulation on existing firms comes from a comparative investigation of manufacturing innovation in the UK and Spain during the 2002-2004 period in which Mate-Sanchez-Val and Harris (2014) found that all eight 'factors hampering innovation' were more commonly cited by Spanish firms than in the UK.

It is difficult a priori to be certain how the stronger public sector influence will influence firms' innovation objectives or knowledge acquisition strategies. The effects of stronger regulation in the Spanish economy are perhaps easier to anticipate. A heavier regulatory burden may limit firms' innovation objectives, although the available evidence relates to ambitious entrepreneurship rather than innovation per se (Levie and Autio 2013). Stronger regulation also increases the regulatory risks associated with new-to-the-market innovation, where innovators face uncertainty as to whether or not new developments may contravene regulation. This may lead to more incremental innovation strategies due to regulatory-risk aversion (Eichler et al. 2013; Sass 1997), which may suggest that non-interactive knowledge acquisition strategies will be favoured over interactive strategies in Spain.

4. Data and Methods

Our analysis is based on the UK and Spanish contributions to the EU Community Innovation Survey covering the period 2004 to 2016. In the UK, the UK Innovation Survey (UKIS) is conducted every two years, with each survey conducted by post using as a sampling frame the Interdepartmental Business Register, with structuring by sizeband, region and sector. Surveys are non-compulsory and achieved response rates ranging from 51.1 per cent in CIS7 (2010) to 58 per cent in CIS4 (2004)[4]. For Spain our analysis makes use of data from the "Panel of Technological Innovation" (PITEC). The PITEC comprises data collected annually by the Innovation in Companies Survey and is Spain's input to the Community Innovation Survey[5]. The PITEC is based on four samples targeting different firms' populations: a sample of larger firms listed on the Spanish Central Company Directory (DIRCE); firms with intra-mural R&D drawing on the Research Business Directory (DIRID) (Vega-Jurado *et al.* 2009); and two samples of smaller firms (with less than 200 employees) that report external R&D, but no intramural R&D expenditures, and that report no innovation expenditure. Both the UK Innovation Survey and the PITEC apply the definitions and type of questions defined in the OECD Oslo Manual (2005) providing the basis for a direct comparison. For innovating firms – i.e. those that undertook innovation in products or services, or processes - both surveys provide detailed information on the objectives of firms' innovation activity and their knowledge acquisition activities. In addition, both surveys provide information on a range of other workplace level characteristics which we use as control variables. Descriptives for all variables used in the analysis are included in Table 2.

[4] See: https://www.gov.uk/government/collections/community-innovation-survey
[5] This dataset is freely available from the National Statistics Institute, INE, on request at: http://icono.fecyt.es/PITEC/Paginas/descarga_bbdd.aspx

Our hypotheses relate firms' knowledge search strategies – interactive and non-interactive - to their innovation objectives suggesting two estimating equations where KSI_i and $KSNI_i$ are interactive and non-interactive search respectively:

$$KSI_i = \beta_o + \sum_{j=1}^{11} \beta_j \, OBJ_{ji} + \beta_{12} CONT_i + \varepsilon_i$$

$$KSNI_i = \gamma_o + \sum_{j=1}^{11} \gamma_j \, OBJ_{ji} + \gamma_{12} CONT_i + \varepsilon_i$$

In each model OBJ_{ji}, j=1-11 are the eleven different innovation objectives identified in the innovation surveys and $CONT_i$ is a set of control variables.

Dependent variables

We define two dependent variables relating to the extent of firms' interactive knowledge search activity and non-interactive knowledge search. In the UK Innovation Survey and the PITEC we find the following question: 'Which types of co-operation partner did you use and where were they located?', with seven potential innovation partner types being identified[6]. We use this data on the extent or breadth of firms' innovation co-operation to measure the extent of firms' interactive knowledge search. Specifically, following (Laursen and Salter 2006) and (Moon 2011), we construct a count indicator which takes values between 0, where firms had no innovation partners, and a maximum of 7 where firms were collaborating with all partner types identified. Innovating firms in the UK had an average of 1.76 interactive partnerships compared to 1.18 in Spain (Table 2). Similarly, we measure the extent of firms' non-interactive knowledge search in a similar way using responses to the question: 'How important to your firm's innovation were each of the following data sources?' Here, we focus on three groups of knowledge sources which are available on a consistent basis for the UK and Spain and different waves of the UKIS and PITEC: (1) conferences, trade fairs, exhibitions; (2) scientific journals and trade/technical publications; and, (3) professional and industry associations. Our indicator of non-interactive knowledge search therefore takes values between 0, where the firm is not engaging in any non-interactive knowledge search activity, and 3 where it uses each non-interactive data source. On average innovating firms in the UK were using 1.74 non-interactive knowledge sources compared to 2.0 in Spain (Table

[6] These were: other enterprises within the group; suppliers of equipment, materials, services or software; clients or customers; competitors within the industry or elsewhere; consultants, commercial labs or private R&D institutes; universities or other higher education institutions; government or public research institutes. In the PITEC, the latter is split into two, public research institutes and technological centres, which we summarized so as to be consistent with the UKIS.

2). While the differences are small, non-interactive partnerships seem somewhat more important in the more highly regulated economy Spain, which tentatively suggests lower ambition.

Innovation Objectives

The other key variable in our analysis reflects the objectives of firms' innovation activity. This is derived from a PITEC/UKIS question which asks: 'How important were each of the following factors in your decision to innovate in goods or services and/or process(es)?'. Eleven alternative objectives for engaging in innovation are distinguished in the various waves of the UKIS and PITEC (Table 2) which we associate with one of the three broad innovation objectives (i.e. new products/services; improved products/services; process innovation), and the cross-category objective of reducing environmental impact, which are the foci of our hypotheses (Figure 1). New products/service innovation we associate with objectives either to increase firms' range of goods or services, increasing market share or enter new markets. New products or services were highlighted as innovation objectives by 43-49 per cent of innovating firms in the UK and 39-50 per cent in Spain (Table 2). Improving products or services we measure using the objectives of improving the quality of goods and services, meeting regulatory[7] or health and safety requirements and replacing outdated products. 23-56 per cent of innovating firms in the UK cited these objectives compared to 25-53 per cent in Spain. Process improvements are measured by objectives to either improve flexibility and the capacity for producing goods or reduce costs. These innovation objectives were cited as important by 31-32 per cent of innovating firms in the UK and 26-33 per cent in Spain (Table 2). Finally, the innovation objective to reduce a firm's environmental damage was cited as important by 38 per cent of firms in the UK compared with only 25 per cent of firms in Spain.

Control variables

We also include in our analysis four variables which previous studies have linked to dimensions of innovation activity. First, we include a binary indicator of whether or not a firm has an in-house R&D capability (Love and Roper, 2001, Love and Roper, 2005, Griffith et al., 2003) which we anticipate will be positively associated with the acquisition of external knowledge. In our sample of innovators 54 per cent of UK firms had an R&D capability

[7] The question in the UKIS focuses on general regulation including standards, the question in the PITEC focuses on environmental and health & safety regulations.

compared to 68 per cent in Spain. The lower percentage for Spain is consistent with the lower levels of R&D activity in Spain, as discussed in section 3. Second, we include a variable reflecting the strength of firms' human capital – the percentage of the workforce which are graduates (Leiponen, 2005, Freel, 2005, Hewitt-Dundas, 2006). On average, 24 per cent of innovating firms' workforce are graduates in the UK compared to 31 per cent in Spain (Table 2). Third, we include employment in the estimated models to reflect the scale of plants' resources. Finally, to capture any market scale effects we include a binary variable indicating whether or not a firm was selling in export markets. Previous studies have linked exporting and innovative activity through both competition and learning effects (Love and Roper 2013). On average the proportion of innovating firms which were exporting was 44 per cent in the UK and 75 per cent in Spain, a contrast which was rather unexpected given earlier arguments that international market conditions were potentially a stronger influence on innovation in the UK than in Spain (Mate-Sanchez-Val and Harris, 2014).

Estimation strategy

Our estimation strategy follows previous studies which have considered the determinants of the extent of firms' interactive connections (Moon 2011). As the dependent variables both in the models for the extent of firms' interactive and non-interactive connections are count variables either Poisson or Negative Binomial models are appropriate. The choice between these models depends on the underlying distribution of the data, however, estimation results using each approach are often, as here, very similar. Another standard consideration in these count models is whether the number of observations taking value '0' accords with the underlying distribution. Often this is not the case and data demonstrate a larger proportion of zeros than would be consistent with the underlying distribution. In this case, models which explicitly allow for the 'inflated' number of zeros are used. These models are known as zero inflated Poisson (ZIP) and zero inflated negative binomial models (ZINB) models and each includes an ancillary 'inflation' equation which governs the extent of over-inflation, i.e., the number of extra zeros in the data[8]. In our analysis, AIC and BIC tests consistently suggest the superiority of the zero inflated ZIP and ZINB models and both are reported here[9]. Our estimation sample is based on pooled data from five waves of the UKIS and PITEC

[8] For our whole sample of innovating firms 52 per cent of firms have no interactive relationships while 37 have no non-interactive relationships.

[9] Estimation of either Poisson or negative binomial models suggest almost identical results to those presented here.

innovation surveys, an approach we adopt to allow robust sub-sample estimates. To allow for sectoral and temporal heterogeneity we also include sector dummies at the 2-digit level and wave dummies in each model.

5. Estimation results

We divide the presentation of results into two main sections. First, we report baseline models for the whole group of innovating firms relating interactive and non-interactive connections to their innovation objectives. Second, as previous studies have suggested potential differences in the determinants of firms' interactive connections by sector (Moon 2011), we report sub-sample estimates for specific groups of firms by industry. These sub-sample estimates also provide a robustness check on the full sample estimates.

5.1 Results for all firms

Baseline models of the extent of firms' interactive and non-interactive search strategies for the whole group of innovating firms are reported in Table 3. Columns 1-4 relate to the UK and columns 5-8 to Spain. In each case we report, ZIP and ZINB models for interactive and non-interactive search. Both models are included for robustness and results prove similar across all estimation. Our first hypothesis relates to the potential for a complementary connection between interactive and non-interactive search in firms' knowledge acquisition strategies[10]. Positive and strongly significant coefficients on both interactive and non-interactive search in the UK and Spanish models provide strong support for this hypothesis, a result which proves robust across different estimation approaches. The implication is that firms engaging in interactive knowledge search are also more likely to be engaging in non-interactive search and vice versa. As indicated above, this complementarity may arise either from the different types of learning processes - exploratory and exploitative – implicit in interactive and non-interactive search, and/or from economies of scope as firms learn how to better manage and co-ordinate their external search activity (Love, Roper, and Vahter 2014).

[10] We have little insight from previous studies about any complementary relationship between firms' interactive and non-interactive relationships. There is some evidence however of complementarities between specific types of interactive relationships (Roper, Du, and Love 2008).

One interesting aspect of this complementarity is the existence of an inverted U-curve effect of non-interactive knowledge search on interactive search in Spain, while this is not present in the UK. For both countries, we find an inverted U-curve effect of interactive search on non-interactive search. This suggests that firms that collaborate more, eventually imitate less. It could be that at some point, firms have gained sufficient knowledge from collaboration, which supersedes any knowledge that could be gained from imitation or copying. It seems to be the case that the additional connections serve not only to diminish the innovation returns of external networking (Laursen and Salter 2006; Leiponen and Helfat 2010; Srinivasan et al., 2021; Grimpe and Sofka 2009; Garriga, von Krogh, and Spaeth 2013), but even the innovation returns from non-interactive knowledge search.

Our remaining hypotheses focus on the connections between firms' innovation objectives and their knowledge acquisition strategies. Hypothesis 2 argues that interactive search, which facilitates exploratory learning processes, will be more strongly related to innovation strategies which emphasise the introduction of new rather than improved or upgraded products. The evidence from our baseline models for the UK and Spain, however, provides little support for this view. Firstly, in both the UK and Spain, non-interactive search is related to virtually all innovation objectives, specifically also those related to new products. Secondly, only one out of the three new-product related innovation strategies – entering new markets – is associated with interactive search in the UK. Additionally in Spain, the objective of increasing the range of goods and services is related to interactive search, but also to non-interactive search. However, whilst for the UK, all improvement-related innovation objectives are also associated with interactive search, in Spain there is no such association at all. Overall, our results therefore provide little support for Hypothesis 2 with one potential explanation relating to the nature of the innovation objectives included in the UKIS/PITEC surveys. These relate specifically to 'near-market' development activity focussed specifically on the introduction of new products/services and processes and exclude more basic technological development activities. It may be that interactive, more exploratory learning processes are more strongly linked to basic research with a less clear distinction between the more applied activity covered by our data sources[11].

[11] The OECD Frascati manual defines the types of R&D activity as follows: Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts without any particular application or use in view; Applied research is also original investigation undertaken in order to acquire new knowledge. It is however, directed primarily towards a specific practical aim or objective; Experimental development is systematic work … that is directed to producing new

Hypothesis 3 suggests that where firms' innovation objectives relate to product or service improvements, non-interactive connections will be more common. We find strong support for this hypothesis for Spain, but no support for the UK. In Spain, all product/service improvement objectives considered are significantly associated with non-interactive knowledge acquisition strategies, while they are not associated at all with interactive strategies. By contrast in the UK all of these innovation objectives are associated with both, non-interactive as well as interactive knowledge search (Table 3). In our baseline models the equation coefficients therefore provide only mixed support for Hypothesis 3.

One notable contrast between the UK and Spain here is the impact of the need to meet regulatory requirements on firms' innovation strategy. In the UK, regarded as having the less onerous system of business regulation (Capelleras et al. 2008; World Bank Group 2020), meeting regulatory requirements has a significant effect on both types of firms' knowledge acquisition strategies. In Spain, where the question related to complying with environmental and health & safety regulations rather than, as for the UK, with a more generic measure of regulation, there is no significant effect on interactive knowledge acquisition strategies but a strong positive impact on non-interactive knowledge search (Table 3). In other words, the need to meet more complex regulatory needs in Spain is linked to more non-interactive knowledge search by firms. Two issues are worth noting here. First, Spanish firms are seeking to address the regulatory challenges they face through non-interactive rather than interactive knowledge search, i.e., through copying, imitation or using already codified knowledge rather than more exploratory partnering. This may reflect the risk-reward balance in innovative activity focussed on meeting regulatory requirements rather than, say, on market expansion. Secondly, while even this type of non-interactive knowledge acquisition is likely to be imposing a cost burden on Spanish firms, contrary to expectations the cost burden faced by UK businesses seems to be even greater, although the comparison is hindered by the different contents of the regulation question in the two countries' questionnaires.

Our fourth hypothesis suggests that non-interactive knowledge acquisition will be most strongly associated with process innovation objectives. We find some support for this hypothesis. In both countries, the innovation objective related to process flexibility is associated with non-interactive knowledge acquisition strategies (Table 3) – in Spain, this association is much stronger than that with interactive knowledge acquisition strategies,

---

materials products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed (OECD 2002) while in the UK, there is no association with interactive search here. Moreover, in both countries the innovation objective of reducing costs is only and strongly associated with non-interactive search strategies. The identified link between process innovation objectives and non-interactive search may reflect the incremental nature of much process innovation as firms steadily seek to improve productive capacity. Incremental process changes – and related non-interactive search strategies – may also require lower levels of management engagement than more interactive relationships and therefore be more widespread (Ashok et al. 2016).

Our final hypothesis suggests that the innovation objective of reducing environmental impact is significantly related to both, interactive (Hypothesis 5a) and non-interactive (Hypothesis 5b) knowledge acquisition strategies. This is strongly supported by the results for both countries. There is no significant difference between the association with interactive versus non-interactive search strategies for the UK, but in Spain the association with interactive search strategies is much stronger than with non-interactive search and stronger than for the UK. In terms of new environmental product development, this may be related to the recent emphasis of Spanish innovation policy which has included the stimulation of technological and product innovation. Moreover, it may be related to the lower absorptive capacity of Spanish than UK firms.

5.2 Sub-sample results

Given the established differences between innovation behaviours across sectors and the rather different composition of industry in the UK and Spain (Mate-Sanchez-Val and Harris 2014) it is interesting to examine the consistency of our aggregate results for sample sub-groups. Table 4 reports sub-sample estimation for manufacturing and services firms. In each case the models follow the same structure as the baseline models and include wave dummies.

Our aggregate models suggest strong support for Hypothesis 1 and the complementarity between interactive and non-interactive knowledge search. For Spain, this result is consistent across both manufacturing and services firms (Table 4). For the UK, however, there is no complementarity between non-interactive and interactive search for services firms. Consistent with the baseline results for the whole sample, we also find little support for Hypothesis 2 across broad sectors for both countries. Hypothesis 3 suggests a stronger association between non-interactive knowledge search and product/service improvement and at an aggregate level we find mixed support for this contention overall – strong support for Spain and no support for the UK. This too is relatively consistent across broad sectors although the evidence for Spain is more consistent than that for the UK. Where there are differences in the sectoral sub-samples (Table 4), these can in both countries be observed mainly for the objectives of improving health & safety and replacing old products. The results for the effect of meeting regulatory requirements in particular are strongly consistent with those for the baseline models in both countries across sub-samples (Table 4). Hypothesis 4, relating to the association between process innovation objectives and non-interactive knowledge search is only weakly supported by the sub-sample results and more so for Spain than for the UK. Only Hypothesis 5a of a significant association of the innovation strategy to reduce environmental impact with interactive knowledge search is supported by the sub-sample results for service sectors for Spain, whereas only Hypothesis 5b of a significant association with non-interactive knowledge acquisition strategies is supported for the UK. However, the sub-sample results for Spain are consistent with the baseline results in that interactive search is significantly more important for reducing environmental impact than non-interactive search strategies.

Alongside the variables of interest we include four control variables in our analysis which suggest some further contrasts between the determinants of knowledge search strategies in Spain and the UK. Firm size, for example, is positively associated with interactive search in Spain but with non-interactive search in the UK. Exporting has a significantly negative association with interactive search strategies in the UK but is positively associated with non-interactive search. By contrast, in Spain, exporting is positively related to interactive search but unrelated to non-interactive search. This positive association with interactive connections may reflect the need for firms to remain innovative in order to compete effectively in international markets, where competition from more advanced economies may increase the need for more radical and less incremental innovation and hence favour interactive collaboration, although it is surprising that this positive link does not also operate in the UK. It may be that the link between exporting and innovation or R&D in the UK operates mainly for businesses' own innovative activity rather than external knowledge acquisition; which may find some support from the data showing higher R&D investment by, and R&D capabilities of, firms in the UK than in Spain (Section 3 and Tables 1 & 2). Spain's lack of an association of exporting with non-interactive strategies which include imitation might be related to imitation increasing vulnerability to external competition (Lieberman and Asaba 2006), in particular perhaps of firms in less advanced economies such as Spain, so other things equal exporting firms may tend to avoid non-interactive search. The proportion of graduates in the workforce is positively associated with interactive search in both countries as well as non-interactive search in the UK, but negatively related with non-interactive search in Spain. The latter might be due to graduates being mainly involved in firms' collaborative projects, therefore raising the interactive but decreasing non-interactive activities. In-house R&D spend is more strongly associated with external knowledge search in Spain than the UK. One possibility is related to recent suggestions that, as mentioned in section 3, innovative responses to regulation will depend on firms' capabilities (Ford, Steen, and Verreynne 2014). Thus where regulation is more stringent, capabilities, including R&D capabilities, may be a more decisive factor in innovation.

6. Conclusions

Firms can acquire the knowledge necessary to drive innovation either through internal discovery processes or through external search (Chesbrough 2007; Chesborough 2006). Here, using data on large samples of UK and Spanish companies, we examine the factors which determine two different modes of knowledge acquisition activity: interactive connections which may be exploratory in character and in which there is a mutuality to learning, and non-interactive search strategies in which knowledge flows from one party to another and learning is therefore one-sided (Glückler 2013).

In terms of our hypotheses three main empirical results stand out. First, we find strong and consistent support for complementarity between non-interactive and interactive connections across firms in all sectors and across both countries. In other words, firms which have more interactive connections as part of their innovation activity also have more non-interactive connections. On the basis of our survey data we are, however, unable to distinguish whether this complementarity is due to differences in the functional content of these connections (Faems et al. 2010; Lavie and Rosenkopf 2006), economies of scope in their management and coordination (Love, Roper, and Vahter 2014), or both. Second, we find some evidence that where firms have innovation objectives which relate to product or service improvements they are more likely to establish non-interactive rather than interactive search strategies. Such connections are likely to be exploitative (rather than exploratory) focussed on the application and commercialisation of existing knowledge rather than the creation of new knowledge which might provide the basis for the introduction of wholly new products or services. The link between product and service improvement and non-interactive search is markedly stronger in Spain than the UK, perhaps reflecting the weaker internal capabilities of potential Spanish partners and lower levels of absorptive capacity. Third, the innovation objective of reducing environmental impact is significantly related to both, interactive and non-interactive knowledge acquisition strategies for both countries. This is likely related to the increasing political, social and business awareness of the need to promote an agenda based on smart, sustainable and inclusive growth, which necessitates the reduction of environmental damage by firms.

In terms of the contrasts between the two countries, we find the most substantial differences in the innovation objectives that drive interactive search. In Spain, only the four innovation strategies of increasing the range of goods and services, entering new markets, reducing environmental impact and, improving the flexibility of the production of goods and services are associated with interactive knowledge acquisition strategies. In the UK, interactive search is associated with a wider range of innovation objectives (Table 3). One possibility is that that this narrower range of knowledge acquisition strategies in Spain may be linked to weaknesses in the Spanish innovation system relative to that in the UK. Where other firms or support organisations have weaker internal capabilities for example, the benefits of developing interactive relationships may be lower. Roper et al. (2008), for example, find that interactive or cooperative knowledge search is more important for process innovation in the West Midlands and Wales regions than that for firms in Catalonia. Another possibility is that in Spain the link between process innovation and incremental innovation strategies, which favour non-interactive knowledge acquisition strategies, is strengthened as a result of the heavier regulatory burden. Interactive linkages may also have less value where levels of absorptive capacity are lower. As Mate-Sanchez-Val and Harris (2014, p. 457) comment: ‘innovation spillovers in the Spanish case are more likely to be pecuniary and based on market (i.e. buyer-seller transactions) while those in the UK … are based on non-market interaction usually involving the sharing of a general pool of knowledge and expertise’.

Our analysis suggests one other consistent result across the two countries. We find a consistent and positive relationship between the quality of firms’ human capital and interactive knowledge search. This provides a link between our study and previous analyses which have linked firms' propensity to develop external connections to their internal capabilities – particularly absorptive capacity (Spithoven, Clarysse, and Knockaert 2011; Schmidt 2010; Xia and Roper 2008). It also suggests that one – indirect – benefit of investments or policy initiatives designed to improve firms' human capital will be an increase in inter-organisational connectivity or openness which itself has potentially positive externalities (Roper, Vahter, and Love 2013). Our findings on the impact of human capital on firms' external knowledge search also highlight the contingent nature of such activities. Sectoral factors, such as regulation, may be important but individual firm-level influences – such as skill attributes and firms' innovation objectives – also play a significant role. Such factors may also influence the value which firms' derive from their external connections and in future research we aim to examine how firms' interactive and non-interactive connections contribute to innovation performance.

Differences also emerge between countries particularly in the impact of regulation on firms' knowledge acquisition strategies. Firms in Spain, which face more onerous regulatory pressures than firms in the UK, adopt more extensive non-interactive knowledge search strategies with potential implications for both knowledge diffusion and business costs. This result suggests a role for government to make it easier for firms to meet regulatory requirements, and more importantly to reduce the regulatory burden faced by firms. This could raise ambition and could focus innovation on more productive objectives than meeting regulatory requirements.

Our results suggest which different innovation objectives induce firms to seek interactive and/or non-interactive strategies to access required knowledge. This suggests that policy initiatives to incentivise innovation collaboration could be aligned to firms' particular innovation objectives. In order for such policy initiatives to be designed more effectively, another issue needs to be explored: Different types of interactive and non-interactive knowledge acquisition strategies face different economic characteristics, incentives and problems, which could be supported by individually targeted policies. For instance, interactive collaboration with customers and suppliers differs markedly from collaboration with direct competitors or with universities and higher education institutions. Hence it would be valuable to know the links between different innovation objectives on the one hand and specific interactive and non-interactive knowledge search strategies on the other hand.

Our analysis has a number of limitations. First, we focus here on the relationship between firms' innovation objectives and choice of knowledge acquisition strategies. We identify some commonalities and differences between the UK and Spain but are not able to link these to specific elements of the innovation eco-system in each country. Examining in a comparative context how eco-system factors influence knowledge acquisition strategies would be a useful next step. A particularly interesting element of this more systemic approach might be to consider the role of spillovers in shaping innovation outcomes alongside interactive and non-interactive learning (Roper and Love 2018). Examination of these issues in the context of the different innovation eco-systems and regulatory burdens of the UK and the Spanish economy could provide additional useful insights. Other limitations are common to our own study and other cross-sectional econometric studies: we model correlation rather than causation, and are only able to speculate rather than identify the specific mechanisms which underlie the relationships we identify.

Table 1: Composition of R&D investment and funding: Spain and the UK

	2000	2005	2008	2009	2011	2013	2015	2017	2018
(a) Sectors undertaking R&D									
Spain									
Business	53.7	53.8	54.9	51.9	52.1	53.1	52.5	55.0	
Higher Education	29.6	29.0	26.7	27.8	28.2	28.0	28.1	27.1	
Government	15.8	17.0	18.2	20.1	19.5	18.7	19.1	17.7	
Charity Sector	0.9	0.1	0.2	0.2	0.2	0.2	0.2	0.2	
UK									
Business	65.0	61.4	62.0	60.4	63.6	63.9	66.0	67.1	
Higher Education	20.6	25.7	26.5	27.9	26.0	26.4	25.3	24.3	
Government	12.6	10.6	9.2	9.2	8.6	7.9	6.6	6.6	
Charity Sector	1.8	2.3	2.4	2.5	1.8	1.8	2.0	2.1	
(b) Funding of R&D									
Spain									
Industry	49.7	46.3	45.0	43.4	44.3	46.3	45.8	47.8	49.5
Government	38.6	43.0	45.6	47.1	44.5	41.6	40.9	38.9	37.6
Other national	6.8	5.0	3.8	4.1	4.5	4.7	5.2	5.1	5.0
External sources	4.9	5.7	5.7	5.5	6.7	7.4	8.0	8.2	7.9
UK									
Industry	48.3	42.1	45.4	44.5	45.9	46.2	49.0	53.7	54.8
Government	30.2	32.7	30.7	32.6	30.5	29.1	27.7	26.0	25.9
Other national	5.5	5.9	6.2	6.3	5.9	6.0	6.3	5.9	5.6
External sources	16.0	19.3	17.7	16.6	17.8	18.7	17.1	14.4	13.7

Source: OECD Science and Technology Indicators database.

Table 2: Sample Descriptives: Pooled survey samples - 2008-2016

	UK			Spain		
Variable	Obs	Mean	Std.	Obs	Mean	Std.
Dependent variables						
Interactive	27,148	1.755	2.175	24908	1.182	1.795
Non-Interactive	27,148	1.739	1.274	24908	1.961	1.260
Innovation objectives						
Increase range	27,148	0.475	0.499	24908	0.503	0.500
Increase market share	27,148	0.429	0.495	24908	0.406	0.491
Enter new markets	27,148	0.490	0.500	24908	0.393	0.488
Improve quality	27,148	0.560	0.496	24908	0.532	0.499
Improve health & safety	27,148	0.231	0.421	24908	0.247	0.431
Reduce environmental impact	27,148	0.377	0.485	24908	0.251	0.434
Replace old products	27,148	0.478	0.500	24908	0.327	0.469
Meet regulations	27,148	0.315	0.464	24908	0.288	0.453
Improve flexibility	27,148	0.316	0.465	24908	0.327	0.469
Improve capacity	27,148	0.307	0.461	24908	0.345	0.475
Reduce costs	27,148	0.318	0.466	24908	0.256	0.437
Control variables						
Employment (log)	25,988	3.370	1.088	24908	4.241	1.605
Exporter (0/1)	27,147	0.437	0.496	24908	0.749	0.433
Graduate share (%)	21,656	23.550	30.967	24908	30.480	28.775
In house R&D (0/1)	27,148	0.536	0.499	24908	0.6771	0.468

Table 3: Models for all firms: UK and Spain

	UK				Spain			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Interactive	Interactive	Non-	Non-	Interactive	Interactive	Non-	Non-
	ZIP	ZINB	ZIP	ZINB	ZIP	ZINB	ZIP	ZINB
Non-Interactive	0.137**	0.198***			0.377***	0.372***		
	(0.058)	(0.058)			(0.050)	(0.036)		
Non-Interactive (sqrd)	0.008	-0.003			-0.041***	-0.038***		
			0.125***	0.125***	(0.014)	(0.010)		
Interactive			(0.009)	(0.009)			0.077***	0.077***
			-0.011***	-0.011***			(0.005)	(0.005)
Interactive (sqrd)			(0.001)	(0.001)			-0.007***	-0.007***
	(0.015)	(0.015)					(0.001)	(0.001)
Increase range	-0.005	0.000	0.000	0.000	0.068***	0.079***	0.054***	0.054***
	(0.021)	(0.022)	(0.013)	(0.013)	(0.021)	(0.016)	(0.009)	(0.009)
Increase marketshare	-0.030	-0.026	0.045***	0.045***	0.015	0.009	0.054***	0.054***
	(0.022)	(0.023)	(0.014)	(0.014)	(0.022)	(0.018)	(0.009)	(0.009)
Enter new markets	0.061***	0.072***	0.064***	0.064***	0.106***	0.120***	0.046***	0.046***
	(0.023)	(0.024)	(0.015)	(0.015)	(0.021)	(0.017)	(0.008)	(0.008)
Improve quality	-0.041*	-0.038	0.049***	0.049***	-0.011	-0.011	0.070***	0.070***
	(0.024)	(0.026)	(0.014)	(0.014)	(0.020)	(0.017)	(0.009)	(0.009)
Improve health & safety	0.103***	0.109***	0.015	0.015	-0.005	-0.008	0.032***	0.032***
	(0.029)	(0.031)	(0.016)	(0.016)	(0.025)	(0.022)	(0.010)	(0.010)
Reduce environmental impact	0.056**	0.063**	0.091***	0.091***	0.142***	0.160***	0.024**	0.024**
	(0.028)	(0.030)	(0.018)	(0.018)	(0.024)	(0.020)	(0.010)	(0.010)
Replace old products	0.068***	0.073***	0.001	0.001	0.004	0.004	0.023***	0.023***
	(0.024)	(0.026)	(0.016)	(0.016)	(0.019)	(0.016)	(0.008)	(0.008)
Meet regulations	0.105***	0.112***	0.085***	0.085***	-0.005	-0.008	0.069***	0.069***
	(0.024)	(0.026)	(0.014)	(0.014)	(0.025)	(0.021)	(0.010)	(0.010)
Improve flexibility	0.022	0.025	0.028**	0.028**	0.038*	0.042**	0.026***	0.026***
	(0.023)	(0.025)	(0.014)	(0.014)	(0.022)	(0.018)	(0.009)	(0.009)
Improve capacity	-0.039*	-0.036	-0.030**	-0.030**	0.030	0.032*	-0.015	-0.015
	(0.023)	(0.025)	(0.015)	(0.015)	(0.022)	(0.018)	(0.009)	(0.009)
Reduce costs	0.020	0.025	0.041***	0.041***	0.033	0.037**	0.030***	0.030***
	(0.023)	(0.026)	(0.013)	(0.013)	(0.021)	(0.018)	(0.009)	(0.009)
Employment (log)	0.004	0.004	0.021***	0.021***	0.125***	0.128***	0.005	0.005
	(0.007)	(0.008)	(0.004)	(0.004)	(0.007)	(0.005)	(0.003)	(0.003)

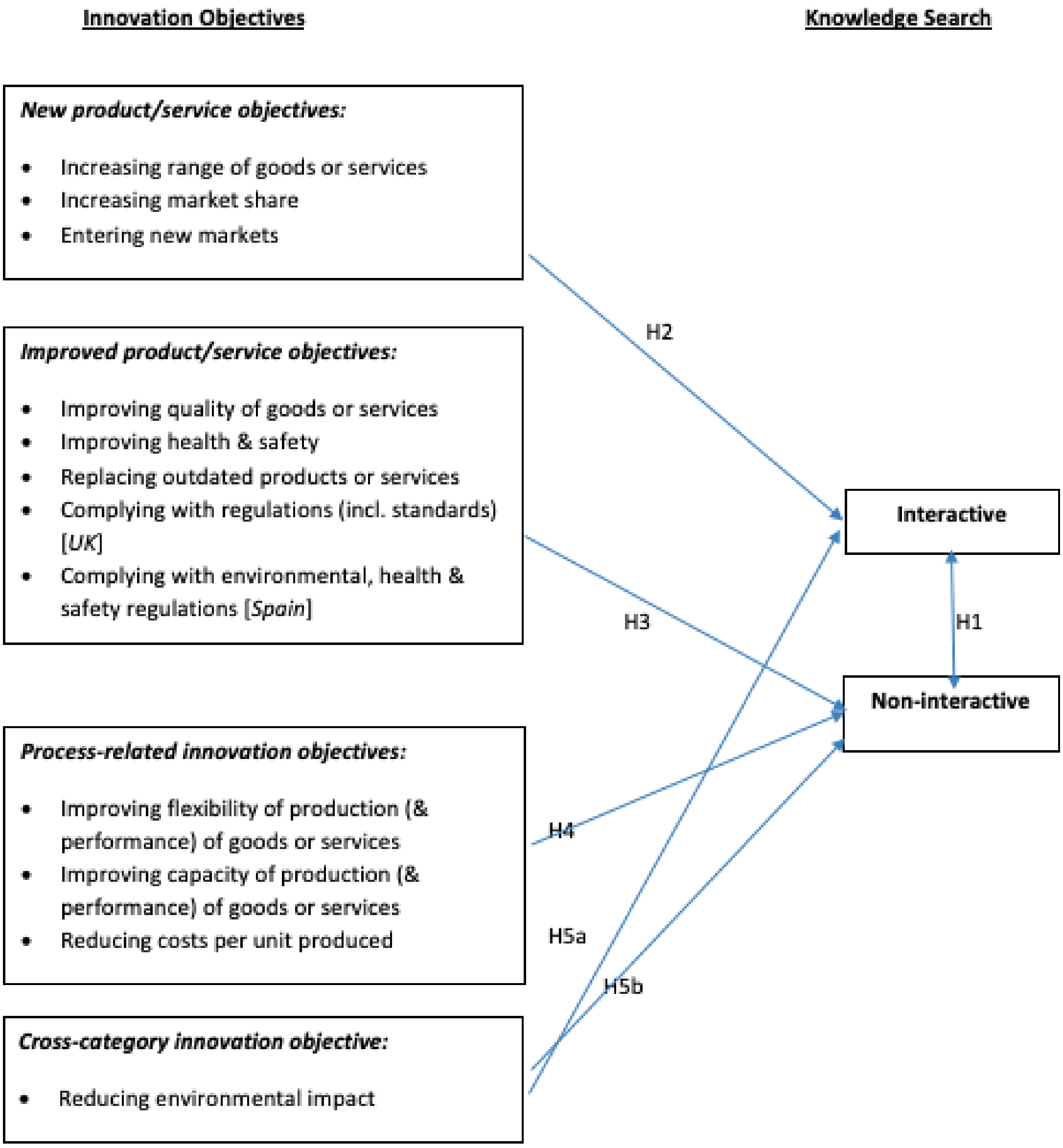
Exporter (0/1)	-0.065***	-0.062**	0.067***	0.067***	0.099***	0.107***	0.005	0.005
	(0.024)	(0.026)	(0.014)	(0.014)	(0.026)	(0.022)	(0.012)	(0.012)
Graduate share (%)	0.001***	0.001***	0.001**	0.001**	0.003***	0.003***	-0.000**	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
In house R&D (0/1)	0.062**	0.061**	0.060***	0.060***	0.628***	0.649***	0.336***	0.336***
	(0.025)	(0.027)	(0.017)	(0.017)	(0.039)	(0.024)	(0.015)	(0.015)
Constant term	0.587***	0.398**	0.184	0.184	-1.273***	-1.350***	0.343***	0.343***
	(0.174)	(0.187)	(0.178)	(0.178)	(0.098)	(0.074)	(0.039)	(0.039)
N	21043.000	21043.000	21043.000	21043.000	24,908	24,908	24,908	24, 908

Table 4: Models for Manufacturing and Services: UK and Spain

	UK				Spain			
	Manufacturing		Services		Manufacturing		Services	
	Interactive	Non-Interactive	Interactive	Non-Interactive	Interactive	Non-Interactive	Interactive	Non-Interactive
Non-Interactive	0.305***		0.095		0.395***		0.354***	
	(0.092)		(0.068)		(0.072)		(0.069)	
Non-Interactive (sqrd)	-0.032		0.018		-0.048**		-0.032	
	(0.024)		(0.018)		(0.020)		(0.020)	
Interactive		0.121***		0.126***		0.077***		0.081***
		(0.013)		(0.012)		(0.007)		(0.009)
Interactive (sqrd)		-0.011***		-0.011***		-0.008***		-0.007***
		(0.002)		(0.002)		(0.001)		(0.001)
Increase range	-0.025	-0.006	0.000	0.007	0.078**	0.059***	0.063**	0.046***
	(0.032)	(0.017)	(0.026)	(0.018)	(0.030)	(0.011)	(0.028)	(0.014)
Increase market share	-0.021	0.049***	-0.031	0.044**	0.033	0.048***	-0.011	0.069***
	(0.030)	(0.017)	(0.027)	(0.018)	(0.031)	(0.012)	(0.030)	(0.014)
Enter new markets	0.098***	0.080***	0.046	0.054***	0.106***	0.047***	0.120***	0.043***
	(0.033)	(0.021)	(0.029)	(0.020)	(0.030)	(0.011)	(0.029)	(0.014)
Improve quality	0.014	0.045**	-0.065**	0.051***	-0.023	0.043***	0.004	0.110***
	(0.030)	(0.019)	(0.031)	(0.019)	(0.029)	(0.012)	(0.028)	(0.015)
Improve health & safety	0.044	-0.004	0.123***	0.028	-0.014	0.046***	0.010	0.012
	(0.037)	(0.021)	(0.037)	(0.021)	(0.035)	(0.013)	(0.037)	(0.016)
Reduce environmental impact	0.048	0.039*	0.056	0.112***	0.108***	0.027**	0.187***	0.011
	(0.041)	(0.022)	(0.035)	(0.023)	(0.031)	(0.012)	(0.037)	(0.016)
Replace old products	0.047	0.057***	0.077**	-0.022	0.001	0.032***	0.015	0.007
	(0.034)	(0.022)	(0.031)	(0.020)	(0.027)	(0.010)	(0.027)	(0.013)
Meet regulations	0.112***	0.044**	0.099***	0.104***	-0.005	0.056***	-0.030	0.090***
	(0.033)	(0.019)	(0.031)	(0.018)	(0.034)	(0.012)	(0.038)	(0.016)
Improve flexibility	-0.004	0.032*	0.034	0.029	0.090***	0.043***	-0.029	0.000
	(0.035)	(0.019)	(0.029)	(0.018)	(0.031)	(0.011)	(0.031)	(0.015)
Improve capacity	-0.041	-0.012	-0.040	-0.045**	-0.023	-0.035***	0.095***	0.007
	(0.033)	(0.019)	(0.030)	(0.020)	(0.031)	(0.012)	(0.030)	(0.015)
Reduce costs	0.037	0.047***	0.013	0.038**	0.078***	0.028**	-0.047	0.040***
	(0.032)	(0.017)	(0.030)	(0.018)	(0.030)	(0.011)	(0.030)	(0.015)
Employment (log)	0.040***	0.037***	-0.009	0.015***	0.145***	-0.001	0.116***	0.011**
	(0.012)	(0.006)	(0.009)	(0.005)	(0.012)	(0.005)	(0.008)	(0.004)

Exporter (0/1)	-0.077*	0.050**	-0.062**	0.076***	0.062	0.006	0.098***	0.011
	(0.041)	(0.022)	(0.029)	(0.018)	(0.062)	(0.019)	(0.030)	(0.015)
Graduate share (%)	0.004***	0.001***	0.001*	0.001*	0.004***	-0.001**	0.003***	-0.000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
In house R&D (0/1)	0.067	0.012	0.062**	0.073***	0.569***	0.351***	0.661***	0.306***
	(0.044)	(0.021)	(0.029)	(0.020)	(0.053)	(0.020)	(0.056)	(0.023)
cons	0.505***	0.352***	0.676***	0.169	-1.436***	0.344***	-1.013***	0.374***
	(0.145)	(0.062)	(0.185)	(0.195)	(0.172)	(0.058)	(0.135)	(0.052)
N	7455.000	7455.000	13588.000	13588.000	15,350	15,350	9,144	9,144

Figure 1. Innovation objectives and (non-) interactive knowledge search – conceptual framework



References

Ambec, S. and P. Lanoie, 2008. Does it pay to be green? A systematic overview. *Academy of Management Perspectives,* **22:45-62.**

Anand, B.N. and T. Khanna. 2000. The structure of licensing contracts. *Journal of Industrial Economics* **48:103-135**.

Anthony, S.D.; M.W. Johnson; J.V. Sinfiled; and E.J. Altman. 2008. *The Innovators Guide to Growth - Putting Disruptive innovation to work*. Boston MA: Harvard Business Press.

Ashok, M., et al. (2016). "How do collaboration and investments in knowledge management affect process innovation in services?" *Journal of Knowledge Management* **20**(5): 1004-1024.

Astebro, T. and J.L. Michela. 2005. Predictors of the survival of innovations. *Journal of Product Innovation Management* **22:322-335**.

Beugelsdijck, P.J. and M. Cornet. 2001. How far do they reach? The localisation of industrial and academic spillovers in the Netherlands. *Centre discussion paper***:47**.

Blind, K. 2012. The influence of regulations on innovation: A quantitative assessment for OECD countries. *Research Policy* **41:391-400**.

Bolton, M.K. 1993. Imitation versus innovation – Lessons to be learned from the Japanese. *Organizational Dynamics* **21:30-45**.

Borgatti, S.P. and D.S. Halgin. 2011. On Network Theory. *Organization Science* **22:1168-1181**.

Boschma, R.A. 2005. Proximity and Innovation: A Critical Assessment. *Regional Studies* **39:61-74**.

Brunetta, F., L. Marchegiani and E. Peruffo, 2020. When birds of a feather don't flock together: Diversity and innovation outcomes in international R&D cooperations. *Journal of Business Research,* **114:436-455**.

Cainelli, G., V. De Marchi and R. Grandinetti, 2015. Does the development of environmental innovation require different resources? Evidence from Spanish manufacturing firms. *Journal of Cleaner Production,* **94:211-220**.

Camagni, R. 1991. Local milieu, uncertainty and innovation networks: towards a new dynamic theory of economic space,. In *Innovation Networks, Spatial Perspectives*, ed. R. Camagni. London, New York Belhaven Press.

Capelleras, J.-L.; K.F. Mole; F.J. Greene; and D.J. Storey. 2008. Do more heavily regulated economies have poorer performing new ventures? Evidence from Britain and Spain. *Journal of International Business Studies* **39**.

Chesborough, H.W. 2006. *Open Innovation: a new paradign for understanding industrial innovation*. Oxford: Oxford University Press.

Chesbrough, H.W. 2007. Why companies should have open business models. *MIT Sloan Management Review* **48:22-+**.

Choi, J. 2020. Mitigating the challenges of partner knowledge diversity while enhancing research & development (R&D) alliance performance: The role of alliance governance mechanisms. *Journal of Product Innovation Management* **37:26-47**.

Dasí-Rodríguez, S., Pardo-del-Val, M. 2015. Seeking partners in international alliances: The influence of cultural factors. *Journal of Business Research* **68:1522-1526.**

De Marchi, V. 2012. Environmental innovation and R&D cooperation: Empirical evidence from Spanish manufacturing firms. *Research Policy*, **41:614-623.**

Dorion, E.; E.T. Pavoni; and L.R. Chalela. 2008. *Innovation or Imitation: A Comparative Study on Common Behavior of Brazilian Entrepreneurs*. Haidian District: Intellectual Property Publ House.

Eichler, H.G.; B. Bloechl-Daum; D. Brasseur; A. Breckenridge; H. Leufkens; J. Raine; T. Salmonson; C.K. Schneider; and G. Rasi. 2013. The risks of risk aversion in drug regulation. *Nature Reviews Drug Discovery* **12:907-916**.

Epstein, R.A. 2013. CAN TECHNOLOGICAL INNOVATION SURVIVE GOVERNMENT REGULATION? *Harvard Journal of Law and Public Policy* **36:87-104**.

EU. 2015. Innovation Union Scoreboard 2015. Brussels: EU Innovation Union.

Faems, D.; M. de Visser; P. Andries; and B. Van Looy. 2010. Technology Alliance Portfolios and Financial Performance: Value-Enhancing and Cost-Increasing Effects of Open Innovation. *Journal of Product Innovation Management* **27:785-796**.

Ford, J.A.; J. Steen; and M.-L. Verreynne. 2014. How environmental regulations affect innovation in the Australian oil and gas industry: going beyond the Porter Hypothesis. *Journal of Cleaner Production* **84:204-213**.

Freel, M.S. and H.W. Aslesen. 2013. The organisational antecedents of openness in small companies. In *25 DRUID Conference* Barcelona.

Frondel, M., J. Horbach and K. Rennings, K., 2007. End-of-pipe or cleaner production? An empirical comparisonof environmental innovation decisions across OECD countries. *Business Strategy and the Environment* **16:571-584**.

Gallego, J., L. Rubalcaba and C. Suárez 2013. Knowledge for innovation in Europe: The role of external knowledge on firms' cooperation strategies. *Journal of Business Research* **66:234-241.**

Garriga, H.; G. von Krogh; and S. Spaeth. 2013. How constraints and knowledge impact open innovation. *Strategic Management Journal* **34:1134-1144**.

Glückler, J. 2013. Knowledge, Networks and Space: Connectivity and the Problem of Non-Interactive Learning. *Regional Studies* **47:880-894**.

Grimpe, C. and W. Sofka. 2009. Search patterns and absorptive capacity: low- and high-technology sectors in European countries. *Research Policy* **38:495-506**.

Hang, C.C.; J. Chen; and A.M. Subramian. 2010. DEVELOPING DISRUPTIVE PRODUCTS FOR EMERGING ECONOMIES: LESSONS FROM ASIAN CASES. *Research-Technology Management* **53:21-+**.

Hassel, A. 2014. Adjustments in the Eurozone: Varieties of Capitalism and the crisis in Southern Europe. In *LSE Europe in Question Discussion Paper*: London School of Economics.

Hewitt-Dundas, N. 2004. The adoption of AMT and innovation strategy in small firms. *International Journal of Innovation and Technology Management* **1:17-36**.

Hewitt-Dundas, N. and S. Roper. 2011. Creating advantage in peripheral regions: the role of publicly funded R&D centres. *Research Policy* **40:832-841**.

Hobday, M. 1995. *Innovation in East Asia: The Challenge to Japan*. Aldershot, UK: Edward Elgar.

Hofmann, C. and S. Orr. 2005. Advanced manufacturing technology adoption - the German experience. *Technovation* **25:711-724**.

Horbach, J., V. Oltra and J. Belin, 2013. Determinants and specificities of eco-innovations compared to other innovations – an econometric analysis for the French and German industry based on the community innovation survey. *Industry and Innovation,* **20:523-543**.

Horn, P.M. 2005. The Changing Nature of Innovation. *Research Technology Management* **48:28-33**.

Jové-Llopis, E. and A. Segarra-Blasco, 2018. Eco-innovation strategies: A panel data analysis of Spanish manufacturing firms. *Business Strategy and the Environment*, **27:1209-1220.**

Kim, L. 1997. *From imitation to innovation: the dynamics of Korea's technological learning* Boston, MA: Harvard Business Press.
Kitching, J. 2006. A burden on business? Reviewing the evidence base on regulation and small business performance. *Environment and Planning C: Government and Policy* **24:799-814**.
Kneller, R. and E. Manderson. 2012. Environmental regulations and innovation activity in UK manufacturing industries. *Resource and Energy Economics* **34:211-235**.
Kopel, M. and C. Loffler. 2008. Commitment, first-mover-, and second-mover advantage. *Journal of Economics* **94:143-166**.
Laursen, K. and A. Salter. 2006. Open for Innovation: The role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal* **27:131-150**.
Lavie, D. and L. Rosenkopf. 2006. Balancing exporation and exploitation in alliance formation. *Academy of management journal* **49:797-818**.
Leiponen, A. and C.E. Helfat. 2010. Innovation objectives, knowledge sources, and the benefits of breadth. *Strategic Management Journal* **31:224-236**.
Levie, J. and E. Autio. 2013. Growth and growth intentions - a meta-analysis of existing evidence: Enterprise Research Centre.
Lieberman, M.B. and S. Asaba. 2006. Why do firms imitate each other? *Academy of management review* **31:366-385**.
Lim, D.J. and D.F. Kocaoglu. 2011. *China - Can It Move from Imitation to Innovation?* New York: Ieee.
Love, J.H. and S. Roper. 2013. SME innovation, exporting and growth: A review of existing evidence. In *White Paper No. 5*. Warwick Business School: Enterprise Research Centre.
Love, J.H.; S. Roper; and P. Vahter. 2014. Learning from openness: the dynamics of breadth in external innovation linkages. *Strategic Management Journal, forthcoming.*
Mate-Sanchez-Val, M. and R. Harris. 2014. Differential empirical innovation factors for Spain and the UK. *Research Policy* **43:451-463**.
Mazon, M.T.; A.M. Martiniano de Azevedo; N.M. Pereira; and M.A. Silveira. 2012. Does environmental regulation foster the diffusion of collaborative innovations? A study on electronics waste regulation on Brazil. *10th Triple Helix Conference 2012* **52:259-268**.
Michie, J. and M. Sheehan. 2003. Labour market deregulation, 'flexibility' and innovation. *Cambridge Journal Of Economics* **27:123-143**.
Moon, S. 2011. What determines the openness of a firm to external knowledge? Evidence from the Korean service sector. *Asian Journal of Technology Innovation* **19:185-200**.
Mueller, V.; N. Rosenbusch; and A. Bausch. 2013. Success Patterns of Exploratory and Exploitative Innovation: A Meta-Analysis of the Influence of Institutional Factors. *Journal Of Management* **39:1606-1636**.
Mukherjee, D., A.S. Gaur, S.S. Gaur, F. Schmid. 2013. External and internal influences on R&D alliance formation: Evidence from German SMEs. *Journal of Business Research* **66: 2178-2185.**
OECD. 2002. *Frascati Manual - Proposed standard practice for surveys on research and experimental development*. Paris: OECD.
Rasiah, R.; V. Gopal; and P. Sanjivee. 2013. Export and innovation in Cambodian clothing manufacturing firms. *Asian Journal of Technology Innovation* **21:305-316**.
Robertson, P.L.; G.L. Casali; and D. Jacobson. 2012. Managing open incremental process innovation: Absorptive Capacity and distributed learning. *Research Policy* **41:822-832**.

Roper, S.; J. Du; and J.H. Love. 2008. Modelling the Innovation Value Chain. *Research Policy* **37:961-977**.
Roper, S.; P. Vahter; and J.H. Love. 2013. Externalities of openness in innovation. *Research Policy* **42:1544-1554**.
Roper, S.; J. Youtie; P. Shapira; and A. Fernandez-Ribas. 2008. Knowledge, Capabilities and Manufacturing Innovation: A US-Europe Comparison'. *Regional Studies*
Roper, S., & Love, J. H. (2018). Knowledge context, learning and innovation: an integrating framework. *Industry and Innovation*, *25*(4), 339-364.
Royo, S. 2007. Varieties of capitalism in Spain: Business and the politics of coordination. *European Journal of Industrial Relations* **13:47-65**.
Sass, H.M. 1997. Moral aspects of risk and innovation. *Artificial Organs* **21:1217-1221**.
Schmidt, T. 2010. Absorptive Capacity - One Size Fits All? A Firm-Level Analysis of Absorptive Capacity for Different Kinds of Knowledge. *Managerial and Decision Economics* **31:1-18**.
Schnaars, S.P. 1994. *Managing Imitation Strategies*. New York: Free Press.
Shenkar, O. 2010. Imitation Is More Valuable Than Innovation. *Harvard Business Review* **88:28-29**.
Simon, H. 1996. *Hidden champions - lessons from 500 of the world's best unknown companies*. Boston, MA: Harvard Business School Press.
Simon, H.A. 1947. *Administrative Behavior: A Study of Decision-Making Process in Administrative Organization* Chicago: Macmillan.
Smith, D.J. and D. Tranfield. 2005. Talented suppliers? Strategic change and innovation in the UK aerospace industry. *R&D Management* **35:37-49**.
Spithoven, A.; B. Clarysse; and M. Knockaert. 2011. Building absorptive capacity to organise inbound open innovation in traditional industries. *Technovation* **31:10-21**.
Srinivasan, R., A. Choo, S. Narayanan, S. Sarkar, A. Tenhiälä, 2021. Knowledge sources, innovation objectives, and their impact on innovation performance: Quasi-replication of Leiponen and Helfat (2010). *Strategic Management Journal*, in press.
Su, C.T.; Y.H. Chen; and D.Y.J. Sha. 2007. Managing product and customer knowledge in innovative new product development. *International Journal Of Technology Management* **39:105-130**.
Suh, Y. and M.S. Kim. 2012. Effects of SME collaboration on R&D in the service sector in open innovation. *Innovation-Management Policy & Practice* **14:349-362**.
Ulhoi, J.P. 2012. Modes and orders of market entry: revisiting innovation and imitation strategies. *Technology Analysis & Strategic Management* **24:37-50**.
Vahter, P.; J.H. Love; and S. Roper. 2014. Openness and innovation performance: are small firms different? *Industry and Innovation*, 21: 553-573.
Van de Vrande, V.; J.P.J. de Jong; W. Vanhaverbeke; and M. de Rochemont. 2009. Open innovation in SMEs: trends, motives and management challenges. *Technovation* **29:423–437**.
Wang, M.-C., P.-C. Chen and S.-C. Fang. 2018. A critical view of knowledge networks and innovation performance: The mediation role of firms' knowledge integration capability. *Journal of Business Research* **88:222-233**.
World Bank Group. 2020. Doing Business 2020: Economy Profile 2020 Spain. New York
———. 2020. Doing Business 2020: Economy Profile UK. New York.
Xia, H. and S. Roper. 2008. From Capability to Connectivity: Absorptive Capacity and Exploratory Alliances in Biopharmaceutical Firms: A US-Europe Comparison. *Technovation* **28: 776-785**

Xu, S. and E. Cavusgil. 2019. Knowledge breadth and depth development through successful R&D alliance portfolio configuration: An empirical investigation in the pharmaceutical industry. *Journal of Business Research* **101:402-410**.

Zammuto, R.F. and E.J. Oconnor. 1992. Gaining advanced manufacturing technologies benefits - the roles of organization design and culture. *Academy of Management Review* **17:701-728**.