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Analysing the drivers of firm-level innovation: a holistic multilevel approach

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Abstract

In this paper, we analyse the importance of adopting a holistic and multilevel approach to estimating the drivers of firm-level innovation. Such an approach includes drivers at individual, firm and national level. It is important to note that failing to consider such multiple levels of determinants may result in omitted variable bias. Our novel research contributes to the innovation literature in a number of ways. Firstly, it estimates multilevel determinants on four types of innovation. This provides a comprehensive and much under-researched analysis of a holistic approach to drivers of innovation. Secondly, we analyse for small, medium and large sized firms, Thirdly, our results, based on a new merged dataset with information from firms across 21 European countries, provide a 'big picture' view of a holistic approach to what drives innovation. The findings reveal that different firm sizes and innovation types warrant different holistic drivers; small firms' innovation activity is determined, for the most part, by what facilities/resources are available inside the firm, while innovation in large and medium sized firms are driven by firm and national level factors.

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Abstract: In this paper, we analyse the importance of adopting a holistic and multilevel approach to estimating the drivers of firm-level innovation. Such an approach includes drivers at individual, firm and national level. It is important to note that failing to consider such multiple levels of determinants may result in omitted variable bias. Our novel research contributes to the innovation literature in a number of ways. Firstly, it estimates multilevel determinants on four types of innovation. This provides a comprehensive and much under-researched analysis of a holistic approach to drivers of innovation. Secondly, we analyse for small, medium and large sized firms, Thirdly, our results, based on a new merged dataset with information from firms across 21 European countries, provide a 'big picture' view of a holistic approach to what drives innovation. The findings reveal that different firm sizes and innovation types warrant different holistic drivers; small firms' innovation activity is determined, for the most part, by what facilities/resources are available inside the firm, while innovation in large and medium sized firms are driven by firm and national level factors.

1. Introduction

Innovation activity is now acknowledged to be a key contributor to economic and firm growth (Fagerberg et al. 2013; Naz et al. 2015). Schumpeter's (1934) theory of economic growth posits that 'creative destruction' and the value firms assign to change, in the form of innovation, constitute the primary sources of growth. Schumpeter is widely considered to be the founding theorist of the contemporary understanding of innovation (Swann 2009; Audretsch et al. 2014). However, the factors driving innovation have over recent decades been a topic of active debate. In particular, national systems of innovation (Lundvall 2010), the geography of innovation (Feldman 1994) and entrepreneurship and innovation (Audretsch 2004) have all garnered considerable attention in the literature, in addition to firm-level drivers, including firm size (Rothwell 1989; Acs and Audretsch 1990), research and development (R&D) activity (Deschryvere 2014), the value of human capital (Gallie and Legros 2012) and management capabilities/style (Fitjar et al. 2013).

Most studies on the drivers of innovation tend to concern themselves either with firm-level characteristics or the effect of the 'outside world', at global, national or regional levels. Such a narrow approach results in a rather limited explanation regarding the

drivers of firm level innovation. We aim to fill this gap in the literature by combining three main factors at firm and national level in order to avoid the possible problems that may arise from a single or narrow approach (Naz et al. 2014). Bridging this gap contributes to innovation theory by emphasising the importance of a holistic approach to the determinants of innovation. The background to this method derives from the theory of national systems of innovation, where Lundvall (2010) explains the importance of national elements, such as, for example, firms and the public sector, and their interactions in increasing knowledge for innovation[1]. Equally, there has been a notable expansion of innovation studies to consider such factors as work processes and labour market issues (Lorenz 2013). However, there remains limited (Naz et al. 2015; Kato et al. 2014) detailed multiple level analysis that examine the driving factors of firm level innovation in a detailed and holistic manner. The latter studies focus on individual countries (Germany and Japan respectively) and for specific firm types. Our study extends such existing research, by blending factors at individual firm and national levels as primary drivers of innovation for a sample of firms across 21 European countries. The research also contributes to the theory of innovation in its analysis for small, medium and large sized firms.

Relying primarily on the recently published European Company Survey 2013 (ECS 2015) data, we merge this with data from the EuroStat[2] and the World Bank[3] for national level information on 21 European Union Member States (see Table 2 for a list and Section 3 for further details). In this novel research we advance the argument for a holistic approach to analysing the drivers of innovation and contribute to innovation literature in three ways: Firstly, we emphasis the importance of estimating multilevel determinants of firm-level innovation. We combine determinants at individual, firm and national level and estimate the effect on four types of innovation. In so doing, we overcome possible omitted variable bias. Secondly, our analysis of small, medium and large sized firms contributes to the call by Manezet et al. (2015) that little is knowledge of the factors driving innovation in small and medium firms.

[1] Due to the limitation of our data we do not include all factors identified by Lundvall (2010). This is be discussed further in Sections 2 and 3.

[2] Eurostat is the statistical office of the European Union (www.eurostat.eu).

[3] World Bank Open Data provides free and open access to data about development in countries around the globe.

Thirdly, our results, based on information from firms across 21 European countries is an approach atypical in innovation studies (with some exceptions, such as Naz et al. (2015)) and provide a 'big picture' view of a holistic approach to the determinants of innovation.

Such a holistic approach to analysing the drivers of innovation is especially important given the complex, non-linear nature of innovation, the challenges in identifying what determines this valuable activity for firms and the central position innovation holds in industrial/enterprise policy at European level (EU 2015).

The remainder of the paper is structured as follows. Section 2 sets out the literature and theoretical background underpinning the research and presents our ten hypotheses. Section 3 discusses the data, our variables and the methodology employed. Section 4 presents insights into the findings from our estimations. Section 5 discusses these results and Section 6 concludes the paper.

2. The conceptual background and research hypotheses

Until recently holistic studies on the drivers of firm-level innovation had been rare.Nielsen et al.'s (2012) study of Danish firms, for example, focuses on the global economic context in relation to employer and employee factors. They found cooperation regarding change and development to be a positive contributor to building capabilities for innovation. Meanwhile, Copus et al. (2008), in their study, found that firm-level factors in general had a greater influence than regional level determinants on the innovation rates across firms in selected regions of Europe. Interestingly, Hitt et al. (2007) suggest the use of multilevel analysis and adopt a multidisciplinary approach to research with regard to theory, measurement and analysis. Although Lorenz and Lundvall's (2011) multilevel analysis centres on creativity in the EU, taking into account the individual, organisational and national contexts, their research provides valuable methodological contributions to the current study. By building on Lorenz and Lundvall's (2011) approach we extend existing studies to include multiple level factors in analysing what drives innovation at the level of the firm.

It is generally acknowledged that no firm operates in isolation and that each depends, to some degree, on outside factors. Equally, innovation activity depends on a myriad of inputs; hence a holistic analysis of the potential drivers of different types of firm level innovation for various firm sizes is presented here. We acknowledge that our analysis of a combination of variables has some limitations due to issues of data availability (an issue we return to in Section 3); however, based on the literature, we provide a robust and usable framework to assess the complex nature of the drivers of four types of innovation in small, medium and large sized firms. Our rationale for distinguishing between different sized-firms can be summarized as follows:

While firms are regarded as learning organisations (Nielsen and Lundvall 2003), small firms are different in nature from large firms, given the distinctive factors that characterise them (Lai et al. 2016). Conflicting views on the impact of firm size on innovation extend as far back as Schumpeter (1934; 1942). Indeed, in his early work, Schumpeter (1934) argued that innovations started in new and small firms but, in his later publication (1942), he pointed to large firms as the primary source of innovation. Furthermore, from the perspective of the neoclassical theory of firm growth, it was assumed that the large firm would cease to grow once it reached its optimal size (Freeman 1982). It has been noted that innovation activity is the primary means through which small and medium sized enterprises (SMEs) grow (Radas and Bozic 2009). Distinguishing between firm sizes can also highlight differences in behaviour in large and small firms' innovation activity (Vaona and Pianta 2008). Few SMEs engage in formal R&D activities, which may underline the importance of external sources of knowledge as an essential input to their innovation activity (Chun and Mun 2012). While small and medium sized firms have been the focus of a number of European policy initiatives aimed at innovation and competitiveness, Manezet et al. (2015) argue that little is known about the factors driving innovation in such firms. It is generally accepted in the literature that firms' external environment may influence small and large sized firms differently (Lai et al. 2016). Furthermore, the same authors highlight that management practices tend to differ between different firm sizes. Consequently, to evaluate multilevel drivers of innovation across different firm

sizes we follow the approach adopted by Deschryvere (2014) in considering small, medium and large sized firms.[4]

2.1 Firm-level innovation

Emerging in the 1980s, innovation theory is founded on economic development, a resource-based view (Teece 1980; Locket and Thompson 2001) and a knowledge-based theory (Grant 1996). The focus of innovation is on learning and enhancing sources of knowledge between stakeholders, such as firms and individuals, and those outside the firm (Lundvall 2010; OECD 1997; Malmberg and Maskell 2002). The theory of economic growth is related to firms' process of identifying new ways of carrying out their business (Schumpeter 1934). Measuring innovation varies from, what is now regarded as, the crude measure of number of patents filed by a firm (Aghion et al. 2015) to the increasingly used self-reported method whereby survey respondents are asked whether an innovation has been introduced by the firm or not (CIS 2015; Bjerk and Johansson 2015). The latter is based broadly on Schumpeter's (1934) list of innovation types and is adopted in the current study, as explained further in Section 3.

2.2. Drivers of innovation activity

The reasons why some countries are innovation leaders and others are not, or why one firm innovates and another does not, perplex many and provoke endless debate amongst academics (Porter 1990; Montalvo 2006). The current research contributes to this debate around what drives innovation by addressing factors at individual firm and national levels as primary drivers of innovation.

2.2.1. Firm-level hypotheses – the role of firm factors in their innovation activities

In terms of the theory of firm growth, Penrose (1959)[5] stresses the importance of firms' idiosyncratic resources, including in-house knowledge, skilled personnel and

[4] We adopt the standard European enterprise size definition, where small firms have 10-49 employees, medium firms have 50-249 employees and large firms have 250+ employees (European Commission 2016).

efficient procedures. Locket and Thompson (2001) note that each firm's collection of resources is unique. Since the 1980s, the Resource Based View (RBV) of the firm, founded primarily on the work of Penrose (1959) and Teece (1980), has refocused attention on internal sources of competitive advantage (Foss et al. 1995). Foss (2005) focuses on the knowledge-based perspective of the firm and the importance of, what Antonioli et al. (2010, p.456) term, 'new organizational practices'. Such practices include team working, autonomy of teams and delegation of responsibilities, which contribute to a firm's absorptive capacity (Antonioli et al. 2010). Given that the literature establishes the importance of such resources and capabilities for innovation, these form the bases for our hypotheses related to firm-level drivers of innovation.

Firms' dynamic capacities: From the RBV of the firm literature, capabilities are intangible and embedded in a firm's routines, structures and systems but can enable innovation (Ayuso et al. 2011). In this respect, it is essential for firms to change to cope with developments in technology and the unstable market (Calantone et al. 2002). Teece and Pisano (1994) highlight the competitive advantage that firms can garner from their dynamic capabilities[6]. Thus the organisational setting for such capabilities to exploit their resources in pursuit of innovation include the way work is organised (Heinonen and Korvela 2008) and its willingness to change (Calantone et al. 2002), hence our first hypothesis is:

H1a*: Firms'* dynamic capabilities have a positive effect on firm-level innovation

*Firms' i*ntrapreneurial enabling environment: A firm can be described as an institution that innovates, creates, coordinates and protects knowledge (von Krogh and Wallin 2011). A firm's strategies, structures and behaviours can thus support innovation (Martins and Terblanche 2003). In this regard, a firm that rewards and encourages independence of thought, facilitates its employees to fully explore a given problem, provides open, high-quality communication and mobilises employee teams, enables intrapreneurship (Seshadri and Tripathy 2006; Bostjan et al. 2001; Pinchot

[5] First published in 1959, the 1995 edition is used here.

[6] The term "dynamic" refers to the shifting character of the environment; certain strategic responses are required when time-to-market and timing is critical, the pace of innovation is accelerating and the nature of future competition and markets are difficult to determine. The term "capabilities" emphasises the key role of strategic management in appropriately adapting, integrating and reconfiguring internal and external organisational skills, resources and functional competences toward a changing environment (Teece and Pisano 1994).

1986). Coined by Pinchot (1986), intrapreneurship allows employees to develop promising ideas to benefit both the firm and the employee and captures the dynamic nature of entrepreneurship. Most research considers that innovation is the focus of intrapreneurship (De Chambean and Mackenzie 1998; Seshadri and Tripathy 2006) and an important part of organisational development, thus a valuable management tool (van des Sijde et al. 2013). The intrapreneurial environment can benefit the performance of firms of all sizes (Bustjar et al. 2001) and develop the entrepreneurial mindset of employees of all types and levels within firms (Seshadri and Tripathy 2006). To identify the firm characteristics that enable innovation and operationalise our holistic framework on the drivers of firm-level innovation we present the following:

H1b: A *firm's* intrapreneurial-enabling environment has a positive effect on its innovation.

2.2.2 F*irms'* human capital hypotheses – the role of human capital as a driver of firm-level innovation

Since the emergence of knowledge-based theory (Grant 1996) and the seminal work of Cohen and Levinthal (1990), human capital as a source of knowledge and the absorptive capacity of firms have become topics of active debate in the innovation literature. In this regard, it is assumed that individuals possess abilities and skills that can be improved through education (Becker 1964). Human capital can be defined as "a unit-level resource that is created from the emergence of individuals' knowledge, skills, abilities and other characteristics" (Ployhart and Moliterno 2011, p.145). This unit-level resource refers to contexts both generic and specific; it encompasses an individual's cognitive (ability/intelligence, knowledge, skills and experience) and non-cognitive (e.g. personality, emotional stability, openness, reliability, interests and values) traits (Ployhart and Moliterno, 2011). Yet the traditional and predominant measure of human capital in the literature remains, for the most part, confined to capturing levels of educational attainment and, occasionally, training (Arvanitis and Loukis 2015; Bjerk and Johansson 2015). The current research builds on the study of innovative human capital, conceptualised by McGuirk et al. (2015), which refers to a multidimensional approach to measuring human capital which incorporates measures

such as education, training, willingness to change and job satisfaction. In order to operationalise this development, we now include a number of potentially important additional measures, as outlined next, to capture the innovativeness of employees.

Education: While it is essential to consider education as a valuable source of knowledge, the comparative advantage firms reap from having a highly educated workforce may diminish as the numbers with such education increase (OECD 2015). Studies based on such a unidimensional approach to assess the contribution of human capital to innovation fail to capture the complexity and intricacies of the individual in a dynamic world. There is, however, an emerging debate in the innovation literature that recognises the wider scope for measuring human capital by including such characteristics as work experience (Ganatakis 2012), job satisfaction (Shipton et al. 2006), attitudes (Fitjar and Rodriguez-Pose 2011) and innovative human capital (McGuirk et al. 2015). This leads us to formulate the first hypothesis to address a multidimensional approach to human capital:

H2a: Employees' third level education has a positive effect on firm-level innovation.

Training: closely related to education, training has been debated in the innovation literature, revealing mixed results. For instance, Gallie and Legros (2012) find in-service training has a positive and statistically significant effect on innovation, which contrasts with Rogers' (2004) finding that management training does not affect innovation in the case of Australian firms. Training has been described by Becker (1964) as being both general and specific; general training increases productivity of the trainee, while specific training can lead to greater productivity for the firm providing the training. As highlighted by Guery and Pendleton (2014), compared to other types of resources, employees cannot be separated from their human capital; investing in such resources may, therefore, be an issue for firms (due to potential free-rider, market failure and public good nature of training). We account for different types of training in our model, as is discussed further in Section 3. The hypothesis is as follows:

H2b: Employees' training has a positive effect on firm-level innovation.

Trust: There is a positive link between trust and firm performance, which is manifested through problem solving (Ruppel and Harrington 2000). Trust facilitates social interaction, increases transparency and reduces uncertainty, as it increases the likelihood of people sharing information and knowledge (Nielson and Nielson 2009). Such sharing of information and knowledge, central to collaboration and developing new ideas, has the potential to result in innovations for the firm (du Plessis 2007). This forms the bases for the following hypothesis:
H2c: Empl*oyees' trust has a positive effect on firm*-level innovation.

Teamwork: The benefits of the use of teams in firms are closely related to those of trust, and are increasingly used to acquire and create new ideas and knowledge (Anand et al. 2003). Research indicates the primary importance of the cross-functional collaborative processes of teams in the context of firms' ability to innovate (Hoegl and Proserpio 2004**).** The independence of teams is important for design thinking and innovation activity in firms (Chang et al. 2013). Hence our final human capital related hypothesis:
H2d: Teamwork among employees has a positive effect on firm-level innovation.

2.2.3. The national-level hypotheses: the role of national factors in driving firm-level innovation

The workforce available to firms, the growth of the economy, the use of public supports and diversity have all been considered as possible influences on firms' innovation activities (Arvanitis and Stucki 2011; Naz et al. 2015; Dakhli and DeClereq 2004; Nielsen et al. 2012; McGuirk and Jordan 2012). To further operationalise our holistic analysis we outline the role of national factors in driving firm-level innovation.

Institutional arrangements: Lorenz and Lundvall (2011) argue that new knowledge can support the development of new products or services (innovation). In the specific case of creativity in the European Union, the same authors find significant positive relationships between institutional conditions at national level and creativity in the workplace. Such institutional conditions include a flexible labour market, which

allows "firms rapidly to bring in new knowledge from the outside and to reconfigure their knowledge bases." (Lorenz and Lundvall 2011, p.278). Continuous (life-long) education and training in the workforce is also regarded as such a condition (Lorenz and Lundvall 2011). Delivering a broad competence-based system of education and training as part of the national system of innovation develops practical, job-related skills in the economy and promotes competences across a wide range of occupational categories. A consideration of these institutional conditions underpins our next hypothesis:

H3a: National institutional arrangements have a positive effect on firm-level innovation.

Diversity: The presence of foreign-born workers leads to cultural diversity in the workforce, which, in turn, provides a variety of perspectives and sources of new knowledge (Solheim and Fitjar 2016). McGuirk and Jordan (2012) find such diversity a driver of product innovation. Diversity is associated with innovation due to its capacity to present ways of thinking differently and, in addition, foreign-born individuals may have international connections to which natives may not have access (Kemeny 2014). This factor, therefore, forms the basis of the next hypothesis:

H3b: Higher levels of national workforce diversity have a positive effect on firm-level innovation.

Economic Creativity: Similar to diversity, creativity can stimulate innovation (Florida 2003). DiPietra (2003) argues that for economic creativity to flourish the environment must be favourable; higher public spending on R&D may, therefore be considered a freedom for firms to improve technologies and know-how. William and McGuire (2010) argue that economic creativity influences innovation implementation. The level of public R&D spending (William and McGuire 2010) and number of patents file per capita (Acs and Audretsch 1990) have been used to capture such creativity in a country. We, therefore, formulate the following hypothesis:

H3c: Economic creativity has a positive effect on firm-level innovation.

Entrepreneurship: Entrepreneurship also constitutes a possible source of knowledge and, hence, a potential contributing factor for innovation (Silverberg et al. 1988). There is a wealth of literature on the link between entrepreneurship and innovation in

this context[7]. Schumpeter states that, "entrepreneurs are a special type, and their behaviour a special problem, the motive power of a great number of significant phenomena" (1934, p.81). Such "phenomena" are related to change and is intrinsically linked to innovation (Audretsch 2004). The level of entrepreneurial activity in an economy is indicated by the number of new start-up businesses (Baliamoune-Lutz et al. 2011). To take account of the number of new business start-ups we pose our penultimate hypothesis:

H3d: Higher instances of entrepreneurship have a positive effect on firm-level innovation.

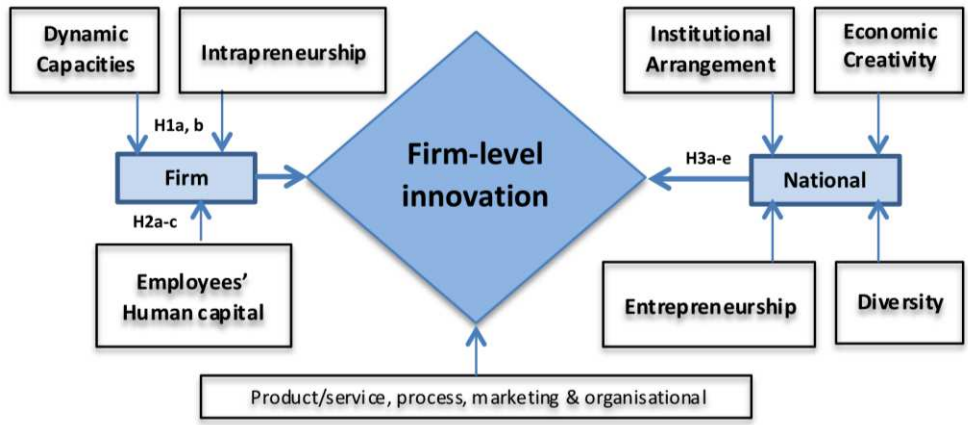
Public support for innovation: It is acknowledge that public support is important for firm-level innovation (Almus and Czarnitzki 2003; Jaffe and Le 2015). As some innovations involve high costs and risks firms creating the related new knowledge may not benefit fully from these investments, which is a source of market failure (Falk 2007). Public policy, particularly enterprise policy, is concerned with providing enabling conditions for innovation and growth (Lenihan 2011). Such support for innovation comes in many forms and the results achieved by it vary. For example, in their study of four European countries Cooke and Wills (1999) found that publicly funded programmes that build social capital through encouraging and incentivising collaboration and networking improved innovation and knowledge in the small and medium firms surveyed. On the other hand, Griffith et al. (2006) found that, while public funding in general was important in supporting innovation, national-level funding had the largest impact (as opposed to supports at European or local/regional level). Czarnitzki et al. (2007) assert that firms in their study would have performed significantly better had they received public funding. In this regard it is interesting to note that Herrera and Sánchez-González (2012) found different effects of public support across different firm sizes. In particular, they found that public R&D subsidies increased private R&D efforts in small firms, but this only prompted expansion in the sale of products 'new for the firm', whereas subsidies in large firms improved the sale of products 'new to the market'. Consequently, to account for policy supports for innovation we formulated the following hypothesis:

H3e: Public support for innovation has a positive effect on firm-level innovation.

[7] The interested reader should refer to the special issue in Small Business Economics on 'Small business, innovation, and entrepreneurship' April 2014, 42(4).

Based on our review of the literature and formation of our hypotheses the study's conceptual framework is presented in Figure 1.

Figure 1: The conceptual framework for a holistic approach to analysing the drivers of firm-level innovation



3. Data and Methodology

The principal dataset used to estimate our ten hypotheses derives from the recently published European Company Survey (ECS 2015). This large dataset provides detailed information on a sample of more than 27,000 firms across 32 countries. The survey comprised telephone interviews conducted during the first half of 2013 with reference to the previous three years (2010-2012 inclusive). The respondents were management representatives (the most senior individuals in charge of personnel) and the focus of the questions explored workplace practices, human resource management, employee characteristics and innovation activities. The target population was establishments with 10 or more employees in all economic sectors except agriculture (ECS 2015). Based on the premise that most innovations happen in private firms (CIS 2015), we extracted privately owned firms (as opposed to publicly controlled organisations). This reduced the dataset to just over 24,000 observations.

We augmented the ECS firm-level data with national-level data from EuroStat and the World Bank's 'Doing Business' survey. To ensure inclusion of as many potential national-level drivers of innovation as possible, we were forced to exclude seven countries, reducing our dataset to just over 16,000 observations (see table 2 for details).

The EuroStat data provided information on diversity, institutional arrangements and economic creativity. Each variable was extracted for each of the 21 countries of our dataset and merged at national level. The eighth wave (2012) of the Community Innovation Survey (CIS- also obtained from EuroStata) provided the information on the number of enterprises that availed of public support for innovation. This information included support from the EU, central government and local/regional government. The World Bank database then provided us with information on 'new business density', a measure of entrepreneurship commonly used in the literature (e.g. Baliamoune-Lutz et al. 2011).

Given our focus on the drivers of innovation in firms of different sizes, we provide estimates for small, medium and large sized firms (approximate 853, 9,705 and 6,343 observations respectively). These figures compare favourably with the number of observations in the full ECS (2013) dataset.

3.2. The variables employed to estimate our hypotheses

This next section provides a detailed description of each of the variables and the method of analysis.

3.2.1. Measures of firm-level innovation - the dependent variable

We use four measures of innovation,[8] which are broadly based on Schumpeter's (1934, p.64) description of innovation. The ECS survey asked whether the firm had introduced any new or improved:

a. product/service;
b. processes;
c. marketing methods or:
d. organisational changes.

This self-reported measure of innovation produces a binary result, namely a value of 1 if the firm innovated during 2010-2012, otherwise 0. Comparing innovation across our dataset, approximately 41% of small firms (with 10-49 employees) reported they

[8] A fifth measure of innovation (introduction of new or improved methods of communicating) is captured by the ECS but limited responses exist and, therefore, they are not used in the current study.

product innovated. This compares with 43% of medium firms (50-249 employees) and 49% of large firms (firms with more than 250 employees). Table 1 provides further details.

3.2.2 Measures of firm-level factors as drivers of innovation, an independent variable

Estimating which dynamic capabilities predict innovation is widely studied in the literature (Frosman 2011). Similar to Calantone et al. (2002), we capture firms' willingness to change (Capab_changeFA) as a measure of dynamic capabilities. This is a set of five questions in the ECS database (see Appendix A for a full list of questions), which refer to changes to remuneration systems, technology, recruitment and working time arrangements. The commonly used Cronbach's alpha measure was used to test reliability of scales (0.7) and factor analysis was performed where the pattern matrix indicated one factor. In order to cope with such changes (Calantona et al. 2002) we employ a binary variable with the value of 1 if respondents agree that training of staff improved and extended the skills used in their current jobs (Capab_improveSkil), otherwise 0. From our sample of the small firms that provided training, 74% provided the training to improve and extend these skills. This was similar to medium firms (77%), while the figure was 84% for large-sized firm. A further measure is based on Nelson (1991) who argues that R&D capabilities are a leader in defining the dynamic capabilities of a firm, though production, marketing and legal organisation must also exist. We, therefore, also include a binary variable with a value of 1 if the firm has in-house design/development (Capab_RD), otherwise 0.

To capture an enabling environment for intrapreneurship to flourish, where employees are valued and supported (Heinonen et al. 2014), we use a binary variable, Intra_CompAdv, where the direct involvement of employees in changes in the firm is considered to give the firm a competitive advantage, taking the value of 1, otherwise 0. Similarly, we use the binary variable, Intra_Involved, which takes the value of 1 if respondents agree with the following statement: 'Employees stay longer in the company when they feel they can get involved' (otherwise the variable takes the value of 0). To capture open communication (Bustijan et al. 2001) within the firm we use two further binary variables, which take the value of 1 if yes, otherwise 0 in relation

to the following two statements related to how work is organised: 'regular meetings between employees and immediate managers' (Intra_meeting_manage), and 'regular staff meetings open to all employees at the establishment' (Intra_meeting_open). Where employees are rewarded is also considered important for such enabling environments (Seshadri and Tripathy 2006) and measured here by two binary variables taking the value 1 if yes, otherwise 0 to the following: extra pay is linked to the individual performance (Intra_payInd); and extra pay is linked to the performance of the team, working group or department (Intra_payTeam).

3.2.*3. Measuring employees'* human capital as a driver of innovation, an independent variable

The multidimensional characteristics of a firms' human capital is captured by education, training, trust and teamwork and comprises four measures. This multidimensional approach reflects the emerging debate in the literature on extending the measure of the individual's contribution to the firm (Ganatakis 2012; McGuirk et al. 2015; Fitjar and Rodriguez-Pose 2011).

Education [Emp_collEd]: This categorical variable indicates the percentage of employees with a university degree and ranges from Category 1, indicating that no employee has a degree, to Category 2 where fewer than 20% have a degree, up to Category 7 where all employees have a university degree. Most firms in our sample (46%) have fewer than 20% of employees with a university degree and 1.7% of firms reported that all of their employees had attained this level of education.

Training: We use three measures of possible training available to employees:

- Specific training (Emp_train), as detailed by Becker (1964) and discussed in Section 2, captures the percentage of employees involved in a job that requires more than one year's training.
- On-the-job training (Emp_training_onthejob) indicates the percentage of employees who availed of training provided by the firm during the previous year. An interesting observation is that 20% of firms do not provide on-the-job training but the same proportion of firms offer all employees on-the-job

training. (Specific and on-the-job training are categorical variables, similar to our education variable).

- 'Time off for training' (Emp_training_timeoff) provides information on the proportion of a firm's workforce that avail of paid 'time-off' for training, a binary variable (1 if employee availed of training, otherwise 0). Overall, just over 22% of employees did not avail of this. In the case of small firms (with 10-49 employees), the figure was 27%.

Teamwork (Emp_team): In order to capture a multidimensional measure of human capital, we include teamwork. As outlined in Section 2, independent teams are important resources for firms to innovate (Hoegl and Proserpio 2004). In the current study, where teams exist in firms (over 80% of total observations), the binary variable takes the value of 1 if team members make decisions on tasks rather than management assigning tasks, otherwise 0.

Trust (Emp_trust): The trust demonstrated between management and employees through involvement in joint planning may establish a relationship and enhance problem-solving necessary for innovation. As discussed in Section 2, such trust contributes to individuals sharing ideas (Nielsen and Nielsen 2009). A total of 49% of respondents to the ECS indicated such trust through joint planning of work tasks by employees and management. This takes the value of 1 where joint planning exists, otherwise 0.

Table 1: Descriptive statistics of firm-level variables

	Large (n=6343) %	Medium (n=9705) %	Small (n=853) %
Dependent variables - Innovation			
Product/Service	49	43	41
Process	47	39	36
Marketing	38	32	31
Organisational	47	36	35
Independent variables			
Firm level factors			
Dynamic Capabilities – Skills	84	77	74
- Willingness to change	34	30	26
- In house design and research	50	49	59
- Regular meetings with management	89	85	83
- Meeting open to all employees	59	56	56
Intrapreneurship – pay based on individual performance	56	49	45
- Employee involvement	86	80	85
- Involvement leads to Competitive Advantage	83	78	77
- Pay based on team performance	38	32	29
Human capital			
Education (< 20% of employees)	49	65	48
Training- specific (<20% of employees)	44	56	51
Training – time-off	41	49	51
Training – on the job	36	45	43
Teamwork	46	42	37
Trust	25	12	33
Controls			
Female employees (<20%)	29	37	26
Employees over50yrs (<20%)	51	51	50
Sectors (NACE2) - Industry	34	40	22
- Construction	7	11	5
- Commerce & Hospitality	25	23	28
- Transport & Communication	6	7	7
- Financial Services & Real Estate	5	3	6
- Other services	23	16	32

3.2.4. Measuring national factors as drivers of firm-level innovation, an independent variable

The third and final factor of concern to the current research is that of the external national-level environment where the firm is located. The literature provides us with extensive examples of factors that may influence innovation in firms and, through the

availability of reliable and high-quality data, we measure five national factors, while acknowledging that this is by no means an exhaustive list.

To address the first of the national-level hypotheses (H3a), related to the national institutional arrangements, we follow Lorenz and Lundvall (2011) to include level of labour mobility (Institutions_LM) and a measure of continuous education/training (Institutions_LLL). We measure labour mobility using EuroStat's 'Labour Force Survey' (2012). This measures the average share of employees who started their job less than 3 months prior to the survey[9]. Life-long learning is a continuous variable that captures the participation rate in education and training over the previous four weeks of the survey. In this regard, the proportion of employed people who had started a job in the previous three months was 4.39% in Austria and 7.57% in Finland.

Diversity (Diversity) the focus of H3b, employs the commonly used (Ottaviano and Peri 2006) measure of number of foreign-born persons as a percentage of the population. In the case of EuroStat, this includes people born in other European Member States and beyond. There are wide variations between countries; for example, in 2012 the percentage of foreign-born people in Poland was 1.64%, Cyprus 23.2% and Austria 16.12%.

Economic creativity (Creativity_RD) is the third national-level hypothesis (H3c). As explained in Section 2, creativity in the economy has the potential to affect innovation in firms through the availability of new knowledge (William and McGuire 2010). EuroStat's 'total intramural R&D expenditure' (GERD)[10] dataset provides us with the euro (€) amount spent on R&D per capita. With an average spend of €444 per capita, the amount varies considerably across the 21 countries. For example, the newer member states of Bulgaria, Croatia, Romania and Poland spend less than €100 per capita on R&D, whereas Finland, Austria and Luxembourg top the table in our sample by spending over €1,000 per capita.

[9] The average over three quarters: the 2nd quarter of 2012 and the 1st and 2nd quarters of 2013 (Lorenz and Lundvall 2010 p. 10).
[10] The number of patents per capita were also considered but results showed a high correlation (.8475) with Public R&D spend.

The fourth national-level factor of concern here is the level of entrepreneurship (entrepreneurship) in the economy (H3d). Similar to Baliamoune-Lutz et al. (2011), we employ data on new business entry density, defined as the number of newly registered corporations per 1,000 people of working age (aged 15–64). From our sample, Estonia has the highest level of entrepreneurship, at 16% and Poland the lowest, at 0.5%. As in the World Bank's report, the units of measurement are private, formal sector companies with limited liability.

While there is much debate around public policy support for innovation output in the literature, the results are inconclusive (Binelli and Maffioli 2007) and acknowledged that direct subsidies are the most important source of public support in Europe (OECD 2014). We evaluate the effect of three levels of innovation support for firms using the EuroStat Community Innovation Survey data (Wave 8, 2012):

- European level (Pub_sup_EU);
- National Government level (Pub_sup_Gov); and
- Local/regional level supports (Pub_sup_loc).

Similar to the use by Griffith et al. (2006) of the three levels of support, this information provides us with the number of enterprises availing of public support for innovation as a percentage of total enterprises in the CIS (2012) survey. We found firms in the Netherlands and Austria availed of the highest level of support for innovation from central government (19.7% and 13.06% respectively) and Romania had the lowest level of support across all three types.

3.2.5. Control variables

A total of three control variables are included. At the firm level, these are the number of employees over the age of 50 (Emp_over50yrs) and the number of female employees (Emp_female). Age is controlled for because it has been found to effect innovation (Frosch 2011). While gender has a small or no significant effect on innovation, we follow most studies by including the level of female employees as a control for gender (Wu et al. 2011). Firm sector (six categories) is also controlled for as this takes account of firm activities and the difference between these, for example manufacturing compared to service sectors (Frosman 2011). The majority of large and

medium firms in our sample are in the 'Industry' sector while 28% of small firms (the majority of small firms) are in the 'Communication & Hospitality' sector.

Table 2: Descriptive statistics for the 21 counties (reference period 2012/2013)

Countries	Number of Observations	1 Entre'hip	2 Diversity	3a	3b Public Policy Supports(funding)	3c	4a Institutional arrangements	4b	5 Economic Creativity
		%	%		%		%	%	€
Austria	893	0.73	16.12	3.32	13.06	8.25	19.10	4.39	1132.40
Belgium	910	2.05	15.66	2.39	6.44	7.17	12.50	3.22	855.20
Bulgaria	467	8.86	1.29	2.43	1.86	0.26	6.90	4.32	36.60
Croatia	387	4.63	13.48	0.78	5.29	1.27	8.50	3.21	83.20
Cyprus	439	13.07	23.20	2.33	8.12	3.90	10.90	4.58	96.80
Czech Rep.	879	3.42	3.68	6.08	4.64	0.99	15.00	2.92	285.00
Estonia	474	16.05	14.97	5.48	8.55	0.60	19.10	4.43	247.00
Finland	889	3.43	5.15	2.62	12.70	4.15	29.80	7.57	1231.70
France	1395	2.26	11.50	2.66	6.99	4.32	23.50	4.26	724.20
Germany	1360	1.29	12.67	2.89	9.39	4.06	14.30	3.58	972.10
Hungary	892	3.66	4.27	5.55	3.81	0.34	8.90	4.60	142.80
Italy	1420	2.32	9.54	1.49	2.73	6.57	11.30	3.07	351.60
Lithuania	410	4.19	4.72	3.62	1.25	0.36	13.10	3.97	111.90
Luxembourg	457	6.1	42.35	0.93	4.94	5.19	19.50	2.98	1127.90
Netherlands	885	5.34	11.49	2.43	19.71	3.63	24.40	3.70	759.50
Poland	1082	0.53	1.64	3.13	1.34	0.73	12.00	3.53	90.30
Portugal	945	4.63	8.40	4.33	9.04	1.62	14.30	4.14	215.40
Romania	480	4.07	0.91	0.70	0.44	0.22	7.30	1.95	27.90
Slovenia	424	4.44	11.30	4.20	7.93	0.71	19.40	3.37	454.10
Slovakia	438	3.1	2.92	2.61	0.75	0.28	9.30	2.08	112.90
Spain	1417	2.97	13.22	0.95	4.07	3.41	15.80	5.14	278.50

1. World Bank (2012) 'New Business Density'. Number of new businesses as a percentage of the population.
2. EuroStat (2012) table number tps00178. Number of foreign-born persons (according to present time borders), as a percentage of the population.
3a (European Support) 3b National Government Support), 3c Local/regional support. -d. inn_cis8_pub Public funding in the enterprises. EuroStat 2012 table number inn_cis8_pub (CIS 2012). Number of enterprises availing of public support for innovation as a percentage of total enterprises in the CIS 2012 survey.
4a. EuroStat (2012) table number trng_lfs_01. Participation rate in education and training (last 4 weeks) by sex and age as a percentage of the population.
4b.EuroStat (2012) table number lfsq_egan / lfsq_egdn2. The percentage of employment share of job starts in previous three months.
5. EuroStat 2012/2013 table number rd_e_gerdtot. Amount (€) spent on R&D per capita.

3.3 Method of analysis

The aim of the empirical analysis that follows is to examine the effects of firms factors (H1) , employees' human capital (H2) and national factors (H3) on four types of innovation (product/service, process, marketing and organisational) in the firm. Our regression function is as follows[11]:

$$I_i = \alpha + + \beta_{1\text{Firm factors}} + \beta_{2\text{employee's human capital}} + \beta_{3\text{National factors}} + \beta_{4\text{controls}} \quad \varepsilon_i$$

where I_i are the four measures of innovation (product/service, process, marketing and organisation), by firm i, of a particular size (small, medium, large). The likelihood of firms innovating is dependent on the firm-level factors, employees' human capital and national factors of the particular country where the firm is located, while controlling for age, gender and sector (details of the individual variables are discussed in Section 3.2 and presented in Table 1, 2 and Appendix A). As the dependent variables are four binary variables, we estimate equation (1) using the logit regression[12] technique.

3.3.1 Methodological issues

To check for multicollinearity, we calculated the correlations between the models' independent variables where variable inflation factor (VIF) results are below 10 in all cases (where the mean VIF is 2.58), indicating that multicollinearity is not a concern among the independent variables in our models[13]. The important econometric issue of endogeneity is considered and, as outlined by Naz et al. (2015), we reduce the risk of such issues by our inclusion of only pre-determinant independent variables; it is unlikely, for example, that firms' innovation will affect diversity at the national level.

[11] While other methods of estimation were considered, (e.g. multilevel modelling) we employ the commonly used regression [Equation 1] (Fitjar et al. 20113; Roper et al. 2010). While Naz et al. (2014) apply a multilevel model to their regional level data where firms are nested in functional regions, our data is at national level and consider firms independent at this level.

[12] The choice of a logit over a probit model is an issue for the researcher to selecting which model to use (Childers 2011). The decision appears one of personal choice, though it merits experimenting with the two models (Childers 2011, p.51). We conducted similar trials and found logit to be a better 'fit' to the dataset.

[13] At the early stages of the analysis we suspected a possible multicollinearity between the measures of economic creativity, noted in Section 2. That is, the number of patents per capita, a measure used by William and McGuire (2010) for economic creativity was highly correlated with R&D spend in the economy. For this reason, we omit the variable.

4. Results

We estimated logit regressions for each of the four types of innovation (four models) across each firm size (small, medium and large), yielding a total of twelve separate regressions. Therefore, for clarity we present our findings for each of the dependent variables separately and present details in Table 3.

4.1 Product/service innovation

We start with the introduction of a new or significantly improved product/service, measured here as 1 if the firm did innovate, otherwise 0. Beginning with the firm-level explanatory variables, dynamic capabilities (H1a) and intrapreneurship-enabling environment (H1b), our results tell a similar story across large and medium sized firms; Firms that facilitate regular meetings with managers and employees are significantly (at the 1% level) more likely to product/service innovate. However, this does not hold true for small firms. There is a positive significance (at the 1% level) where firms consider employees' involvement in work organisation a competitive advantage, indicating that firms are more likely to product/service innovative. We find firms' dynamic capability measure of in-house design/development and firms' willingness to change significant for all innovation types across all firm sizes. In line with Heinonen and Korvela (2008) and Calantone et al. (2002), the strongly positive results re-emphasis the importance of such capabilities for firms innovation activities whatever the type.

In terms of the national-level factors that may drive product/service innovation for firms in our sample of 21 countries in Europe, diversity is positively significant for large and medium firms. Interestingly, most national-level factors are found non-significant for all innovation types in small firms. This indicates that, for such firms, factors inside the organisation are more important, supporting Copus et al. (2008), that firm-level factors have greater influence than regional level determinants on innovation. The control variable for gender is positively significant for all three firm sizes; however, for larger firms with an older workforce (over 50 years old), the results indicate that the higher the proportion of this cohort, the less likely such firms are to innovate, but this is not significant for other firm sizes in our sample. As expected, our results reveal that, in general, firms in non-manufacturing sectors (e.g.

construction, hospitality and other services) are less likely to product/service innovation.

To examine the complementarity between factors driving innovation we re-estimated our regressions to include the interaction between human capital measures and other firm-level factors. Overall, our results show that few such complementarities reached significance. This is similar to the findings of Arvanitis and Loukis (2012) in their study of factors affecting demand for employee education. We can, however, report that the interaction between education and the intrapreneurial measure of competitive advantage (Intra_CompAd) is positively significant for product/service innovation (at the 10% level). An example of non-significance is the interaction between education and diversity.

4.2. Process innovation

In addition to the consistent results across all innovation types, outlined above, process innovation in large firms is driven by education and training, while medium-sized firms in our sample are driven by our measure of education; specifically, we find medium firms are more likely to innovate when 20-39% of their employees have a university degree. This implies that employees' higher education is an important source of knowledge (Cohen and Levinthal 1990; Becker 1964). Those large firms with 40-59% of their human capital requiring specific training are more likely to process innovate. This is also the case for higher levels of specific training (80-99%), as firms with such specialised skills are highly likely to engage in process innovation. Again, in large and medium firms, on-the-job training is strongly significant for process innovation (at the 1% level). The notable results from this model are the positive significant results for all categories of specific training for medium firms only. That is to say, medium firms with any level of specific training are likely to process innovate compared to those firms with no specific training (reference level). With regard to how national factors affect process innovation in our sample of firms across Europe, an analysis of entrepreneurship shows that it is less likely that large and medium firms located in countries with a higher density of new businesses will process innovate. The results for public support for innovation reveal that, medium firms located in countries with higher levels of local/regional government support are less likely to process innovate.

4.3. Marketing innovation

Our results reveal that small firms are more likely to introduce or improve marketing activities if most (above 60%) employees have a university degree and 20-39% of employees require specific training. Comparable results are found for large and medium firms. Similarly, medium and large firms with an intrepreneurial-enabling environment and dynamic capabilities such as open communication, skill improvement are important for their marketing innovation activities. The institutional arrangements of life-long learning and labour mobility are found positively significant for small firms, the only national-level factor significant for such firms, indicating that marketing innovation in small firms depends on such national-level training/learning.

4.4. Organisational innovation

The positive significant result for human capitals' education is striking in its similarities across large and medium sized firms and non-significant for small firms for organisational innovation. Additionally, our results reveal that an intrapreneurial-enabling environment is important for organisational innovation in medium firms and of limited significance for other sizes. With respect to the influence of national factors on organisational innovation, our findings show no reliance on these among small firms. In contrast, large and medium firms located in countries with higher levels of public support for innovation from local/regional government and higher rates of life-long learning among the population and higher level of national R&D spend (measure of economic creativity) are more likely to conduct organisational innovations. . The control variables for this type of innovation show unusual results; the non-significant result for gender and age (in contrast with the significance found for all other innovations across all firm sizes) indicates that age and gender have no effect on organisational innovation in our sample. On the other hand, with respect to the interaction between the independent variables of education and involvement (Intra_Involved), a measure of intrapreneurial environment, this is positively significant.

Table 3: Results from logit regressions (1/2)

	Product/Service Innovation			Process Innovation			Marketing Innovation			Organisational innovation		
Firm Size	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small
Capab_changeFA	0.42***	0.49***	0.43***	0.67***	0.66***	0.10***	0.49***	0.48***	0.61***	0.72***	0.68***	0.72***
Capab_RD	0.89***	0.97***	1.01***	0.69***	0.71***	0.18***	0.68***	0.71***	1.17***	0.38***	0.37***	0.42*
Capab_improveSkil	0.27**	0.34***	0.30	0.34***	0.30***	0.22	0.20*	0.27***	0.10	0.32***	0.34***	-0.33
Intra_involved	0.04	0.00	-0.28	0.09	-0.06	0.27	0.07	0.09	-0.14	0.04	0.01	0.18
Intra_CompAdv	0.18*	0.15*	0.55*	0.16	0.15*	0.22	0.16	0.20**	0.27	0.11	0.16*	0.59*
Intra_payTeam	0.13*	0.14***	0.15	0.13*	0.16**	0.20	-0.03	0.11	0.26	0.07	0.18**	0.10
Intra_payInd	0.25***	0.13**	0.07	0.28***	0.16**	0.18	0.23***	-0.02	-0.21	0.26***	0.19***	0.29
Intra_meeting_manage	0.23*	0.14*	0.05	0.39***	0.14	0.25	0.30**	0.22**	0.09	0.63***	0.25**	0.20
Intra_meeting_open	0.08	0.04	0.01	0.14*	0.06	0.18	0.27***	0.10*	0.23	0.07	-0.09	0.19
_IEmp_CollE_2	0.05	0.20**	0.21	0.08	0.21**	0.27	0.25*	0.35***	0.07	0.44***	0.35***	0.50
_IEmp_CollE_3	0.22	0.36***	0.18	0.21	0.33***	0.31	0.30*	0.48***	0.36	0.71***	0.63***	0.39
_IEmp_CollE_4	0.41**	0.54***	0.24	0.12	0.48***	0.37	0.38**	0.53***	0.28	0.73***	0.60***	0.63
_IEmp_CollE_5	0.13	0.56***	0.51	0.19	0.44**	0.40	0.24	0.54***	1.03*	0.70***	0.65***	0.63
_IEmp_CollE_6	0.32*	0.61***	0.43	-0.11	0.27	0.37	0.23	0.43**	1.24**	0.71***	0.58***	0.74
_IEmp_CollE_7	0.52*	0.15	0.61	0.05	0.25	0.56	0.33	0.40	1.37*	0.62**	0.95***	1.68**
_IEmp_train_2	0.16	0.05	0.02	0.08	0.26**	0.27	0.06	0.02	0.07	0.18	0.20**	0.27
_IEmp_train_3	0.32**	0.19*	0.79**	0.12	0.30***	0.32	0.21*	0.10	0.63*	0.17	0.11	0.58
_IEmp_train_4	0.05	0.23*	-0.11	0.19	0.26**	0.33	0.02	0.23*	0.25	0.06	0.12	0.25
_IEmp_train_5	0.17	0.12	0.18	0.01	0.22*	0.38	0.10	-0.08	0.57	0.16	0.21	0.25
_IEmp_train_6	0.01	0.00	0.20	0.28*	0.25*	0.30	0.23*	0.02	-0.08	0.16	0.19	0.24
_IEmp_train_7	0.07	0.17*	0.08	0.06	0.27**	0.26	-0.04	0.07	-0.01	-0.18	-0.08	0.28

*p< 0.05, **p<0.01; p<0.001

Notes: Emp_CollE and Empl_train categories 1 = reference category is none; 2.<20%; 3.20-39%; 4. 40-59%; 5.60-79%; 6.80-99%; 7.All employees

Table 3: Results from logit regressions contd., (2/2)

	Product/Service Innovation			Process Innovation			Marketing Innovation			Organisational innovation		
Firm Size	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small
Emp_training_time off	0.01	0.03*	0.04	0.02	0.04***	0.04	0.02	0.03*	0.01	0.05**	0.04**	0.03
Emp_training_onth ejob	0.03	0.02	0.03	0.07***	0.05***	0.04	0.05**	0.00	-0.05	0.03*	0.04***	0.03
Emp_team	0.06	0.15**	0.06	0.13*	0.05	0.17	0.07	0.12*	0.20	0.09	0.06	0.05
Emp_trust	-0.09	-0.02	0.13	0.01	-0.01	0.18	0.01	-0.01	0.35	0.04	-0.03	-0.14
Entrepreneurship	-0.04**	-0.04***	-0.02	-0.03*	-0.04***	0.05	-0.01	-0.03**	-0.03	-0.04**	-0.04**	-0.01
Diversity	0.02**	0.03***	0.03	0.01	0.02***	0.02	0.01	0.03***	0.03	0.00	0.01	-0.02
Pub_sup_EU	-0.06*	-0.03	0.02	-0.05	-0.04	0.08	-0.17***	-0.16***	-0.07	0.03	0.01	-0.04
Pub_sup_Gov	0.01	0.02*	-0.02	0.02	0.01	0.03	0.01	0.01	0.00	-0.02	0.02*	0.01
Pub_sub_loc	0.05*	0.04**	0.04	0.03	0.06**	0.06	0.01	-0.03	-0.03	0.17***	0.18***	0.05
Institutions_LLL	0.00	0.01*	-0.02	-0.01	0.00	0.03	-0.01	0.02*	0.00	0.05***	0.05***	-0.02
Institutions_LM	-0.07*	-0.08**	-0.05	0.08*	0.06*	0.10*	-0.09**	-0.17***	-0.11	0.06	-0.04	0.06
Creativity_RD	0.00***	0.00***	0.00	0.00*	0.00***	0.00	0.00	0.00	0.00	0.00***	0.00***	0.00
Control_female	0.07**	0.05**	0.11	0.07**	0.04*	0.06	0.05*	0.05**	0.09	0.03	0.00	-0.04
Control_over50yrs	-0.06**	-0.01	-0.07	0.00	-0.01	0.06	-0.05*	-0.03	-0.15*	0.03	0.01	-0.06
_INACE6_R2_2	-0.61***	-0.60***	-0.78	-0.52***	-0.56***	0.40	-0.14	-0.09	-0.53	-0.15	-0.21*	-0.43
_INACE6_R2_3	0.12	0.25***	0.44	-0.34***	-0.29***	0.24	0.63***	0.81***	0.20	-0.02	-0.06	0.13
_INACE6_R2_4	-0.55***	-0.45***	-0.97*	-0.30*	-0.35**	0.44	-0.34*	0.04	-0.91*	-0.09	-0.25*	-0.30
_INACE6_R2_5	-0.24	-0.14	-0.35	-0.02	-0.42**	0.39	0.04	0.35**	0.22	0.37**	0.08	-0.02
_INACE6_R2_6	-0.18*	-0.28***	-0.43	-0.34***	-0.38***	0.23	0.14	0.23**	-0.69**	-0.08	0.03	0.17
_cons	-1.26	-1.82	-1.82	-2.37	-2.18	0.69	-1.87	-1.85	-1.85	-3.66	-3.03	-2.43

*p< 0.05, **p<0.01; p<0.001

Note: NACE categories: 1 reference category, Industry; 2.Construction; 3.Commerce & hospitality; 4.Transport & Communication; 5. Financial Services & Real Estate; 6 Other services.

5. Discussion

This study contributes to the literature by: 1. estimating multilevel determinants of four types of innovation. 2. analysing these determinants for small, medium and large sized firms; and 3. relying a new merged dataset derived from three sources relating to 21 European countries for the period 2010-2012, we provide a 'big picture' view of a holistic approach to the determinants of innovation. The novelty of our study lies in the holistic approach to the measures employed for both the dependent and explanatory variables for large, medium and small sized firms.

We also contribute to the on-going debate in the innovation literature on different firm sizes (Manezet et al. 2015; Lai et al. 2016). Our analyses reveal that large firms (employing more than 250 people) and medium firms (employing 50-249 people) are more reliant on multiple level factors to drive their innovation activity. In general, firms of these sizes are more likely to engage in innovation where dynamic capabilities exist, an intrapreneurial environment is present and a large proportion of their human capital is educated to university level, specifically trained and display trust. These firm-level drivers are supported by national-level factors where the firm is located, for which positive significance is found for higher levels of diversity in the population and public policy supports from local/regional government.

With respect to drivers of innovation in small firms, our results are broadly in line with Naz et al. (2015) in demonstrating that firm-level determinants are more significant than external/national factors. Our results confirm the important role of a multidimensional approach to human capital and, firms' dynamic capabilities as drivers of innovation. Considering the intrapreneurial-enabling environment in small firms, our results show that firms who consider employee involvement to yield a competitive advantage are more likely to engage in product/service and organisational type innovations. This reiterates the importance of such environments for innovation to thrive (Martins and Terblanche 2003).

It is notable that public support for innovation at EU level, where significant, is negative in our models. This may indicate that supports for innovation are more effectively administered at national and local levels, a point of note for policy makers,

specifically at European level. In this way, our findings suggest that public investment in innovation, while at the heart of EU policy (EU 2015) makes a more positive contribution if operationalised from within the Member State. This is particularly relevant in the case of large firms' marketing and product/service type innovation activity.

Our analysis has implications for theory and practice. Regarding the contribution to theory, there are surprisingly few studies, as outlined in Section 2, that examine individual, firm and national level determinants of innovation in the same analysis. This is important given the complexity of innovation and the strong emphasis on innovation for growth (EU 2015). Our findings suggest that a 'one size fits all' approach is not suitable. By this we mean that, for policy makers, small firms' innovation activity is determined, for the most part, by what facilities/resources are available inside the firm. The European Union policy agenda has addressed issues of workplace practice over many years in the context of the European Employment Strategy (ECS 2015) and evidence from our analyses demonstrates the positive results of such practices. Public support for innovation, therefore, may manifest itself more effectively by indirect means through support for human capital and firm structures highlighted in our findings. This suggestion, particularly in the case of small firms, is bolstered by our non-significant results for public support for innovation from EU, central government or local/regional government levels. The latter area of public support for innovations and moreover, the policy implications of our findings though beyond the scope of the current paper definitely merits further investigation and analysis.

While we believe our analysis provides valuable insights into a 'big picture' view of holistic drivers of innovation across 21 European countries, we acknowledge the absence of seven Member States. This limitation, while an issue to be noted, is mitigated by the inclusion of 75% of the Member States including four of the largest countries (Germany, Italy, Spain and France). An additional limitation relates to our use of secondary data. As expected, such data does not provide perfect measures for all the factors considered. For example, the complexity of human capital warrants a multifaceted set of measures to capture all of its idiosyncrasies. Despite this, most research uses the single proxy of education to operationalise this construct. Based on

the data available to us as well as prior research, we, therefore, include four proxies (education, training, trust and teamwork) as we believe that these provide a more all-encompassing perspective on human capital as a driver of innovation.

6. Conclusion

This research makes three key contributions to innovation theory. Firstly, it emphasises the importance of estimating multilevel determinants of four types of firm-level innovation. Secondly, our analysis of small, medium and large sized firms corroborate the argument that differences exist between firm size (Vaona and Pianta 2008). Our findings also contribute to the call by Manezet et al. (2015) that little is knowledge of the factors driving innovation in small and medium firms. Our study highlights that small firms (10-49 employees) rely on firm level factors more than the national level factors to drive innovation. Thirdly, given the limited number of existing multilevel innovation studies (Naz et al. 2015; Kato et al. 2014) and their focus on individual countries (Germany and Japan respectively) our study of firms in 21 European countries, extends the literature and provides a valuable European wide view of a holistic approach to understanding innovation.

The results from our analysis, in part, point to support for the ten hypotheses presented in Section 2. The caveat is based on our in-depth estimations for different innovation types and firm sizes. For example, we find that hypothesis H1b, a firm's intrapreneurial-enabling environment has a positive effect on its innovation, holds true in the case of marketing and process innovations in large firms. Equally, hypothesis H2d, teamwork among employees has a positive effect on firm-level innovation, is accepted provided firms are medium-sized and active in marketing and product/service innovation.

Our findings are potentially interesting to both firms' management/owners and policy makers, as they provide valuable insights into the utility of a holistic approach to identifying drivers of innovation. These insights combine with our specific findings that different firm sizes and innovation types warrant different holistic drivers. While our research is based on European countries, our analysis also has implications for further studies beyond Europe. A similar approach based on our conceptual

framework could, therefore, be used in a comparative study between countries or regions, for example. Also, future research could make a valuable contribution by analysing the holistic drivers of innovation across sectors.

Appendix:

From ECS (2013) - Please tell me, whether any of the following changes have been made since the beginning of 2010:

a) Changes in the remuneration system
b) Changes in the use of technology
c) Changes in ways to coordinate and allocate the work to employees
d) Changes in recruitment policies
e) Changes in the working time arrangements

References

Acs, Z. J. and Audretsch, D. B. (1990) Innovation and Small firms, Cambridge, Mass: MIT Press.

Aghion P, Akcigit U, Bergeaud A, Blundell R, Hemous D. (2015) 'Innovation and Top Income Inequality', NBER Working Paper No. 21247.

Almus, M., and Czarnitzki, D. (2003) The effects of public R&D subsidies on firms' innovation activities: the case of Eastern Germany. Journal of Business & Economic Statistics, 21(2) 226-236.

Anand, V., Clark, M. and Zellmer-Bruhn, M. (2003) 'Team knowledge structures: matching task to information environment', Journal of Managerial, 15(1), 15-31.

Antonioli, D., Mazzanti, M. and Pini, P. (2010) 'Productivity, innovation strategies and industrial relations in SMEs. Empirical evidence for a local production system in northern Italy', International Review of Applied Economics, 24(4), 453-482.

Antoncic, B. and Hisrich, R.D. (2001) Intrapreneurship: Construct Refinement and Cross-Cultural Validation, Journal of Business Venturing, 16, 495-527.

Arvanitis, S. and Loukis, E. (2015) 'Employee education, information and communication technologies, workplace organization, and trade: a comparative analysis of Greek and Swiss firms' Industrial and Corporate Change, 24 (6):1417-1442.

Audretsch, D., Coad, A, and Segarra, A. (2014) 'Firm growth and innovation', Small business Economics 43, 743-749.

Audretsch, D. B. (2004) 'Sustaining Innovation and Growth: Public Policy Support for Entrepreneurship', Industry and Innovation, 11(3), 167-191.

Ayuso S, Rodríguez, M.A. and Ricart, J.E., (2006),'Using stakeholder dialogue as a

source for new ideas: a dynamic capability underlying sustainable innovation", *Corporate Governance: The international journal of business in society'*, 6(4), 475-490.
Becker, G. S. (1964) Human Capital, Chicago and London: The University of Chicago Press.
Baliamoune-Lutz, M., Brixiová, Z. and Ndikumana J. (2011) 'Credit Constraints And Productive Entrepreneurship In Africa', Working Paper No. 23/2011.
Bjerke, L. and Johansson, S. (2015) Patterns of innovation and collaboration in small and large firms', Annals Regional Science, 55, 210-247.
Calanton, R., Cavusgil, S.T. and Zhao, Y. (2002) 'Learning orientation, firm innovation capability, and firm performance', Industrial Marketing Management 31, 515 – 524.
Chang, Y., Kim, J. and Joo, J. (2013) 'An Exploratory Study on the Evolution of Design Thinking: Comparison of Apple and Samsung', The Design Management Institute, #13081CHA22, p. 22-34
Chun, H. and Mun, S-B. (2012) Determinants of R&D cooperation in small and medium-sixed enterprises', Small Business Economics, 39, 419-436.
Cohen, W. and Levinthal, D. A. (1990) 'Absorptive Capacity: A New Perspective on learning and Innovation', Administrative Science Quarterly, 35(1), 128-152.
Cooke, P. and Wills, D. (1999) 'Small Firms, Social Capital and the Enhancement of Business Performance Through Innovation Programmes', Small Business Economics, 13,219-264.
Copus, A., Skuras, D. and Tsegenidi, K. (2008) 'Innovation and Peripherality: An Empirical Comparative Study of SMEs in Six European Union Member Countries', Economic Geography 84(1), 51–82.
Czarnitzki, D., Ebersberger, B. and Fier A. (2007) 'The Relationship Between R&D Collaboration, Subsidies and R&D Performance: Empirical Evidence From Finland And Germany', Journal Of Applied Econometrics. 22, 1347–1366.
Dakhli, M. and DeClercq, D. (2007) 'Human capital, social capital and innovation: a multi-country study', Entrepreneurship & Regional Development: An International Journal, 16(2), 107-128.
de Chambeau, F. A., and Mackenzie, F. (1986), "Intrapreneurship", Personnel Journal, July.
DiPietro, W. (2003) 'Freedom, boldness, and economic creativity', Knowledge, Technology and Policy, 15(4), 37-45.
Deschryvere, M. (2014) 'R&D, firm growth and the role of innovation persistence: an analysis of Finnish SMEs and large firms', Small Business Economics, 43(4), 767-785.
du Plessis, M. (2007),'The role of knowledge management in innovation', Journal of Knowledge Management, 11(4), 20 – 29.
ECS (2015) European Company Survey 2013, UK Data Archives.
EU (2016) Internal market, Industry, Entrepreneurship and SMEs, website http://ec.europa.eu/growth/industry/innovation/
EU (2015) Horizon2020 website http://ec.europa.eu/programmes/horizon2020/
European Commission (2015) Innovation Union Scoreboard, Directorate-General for Enterprise and Industry. Brussels.
Fagerberg, J., Martin, B. and Andersen, E.S. (2013) Innovation studies: evolution and future challenges, Oxford: Oxford University Press.

Falk, R. (2007) ‘Measuring the effects of public support schemes on firms’ innovation activities Survey evidence from Austria’, Research Policy, 36(5), 665–679

Feldman, M. P. (1994). The Geography of Innovation. Economics of Science, Technology and Innovation. Dordrecht; Kluwer Academic Publisher.

Fitjar, R. and Rodriguez-Pose, A. (2011) 'Innovating in the periphery: Firms, Values and Innovation in Southwest Norway', European Planning Studies, 19(4), 555-574.

Fitjar, R., Gielsvik, M. and Rodriguez-Pose, A. (2013) 'The combined impact of managerial and relational capabilities on innovation in firms', Entrepreneurship & Regional Development, 25(5-6), 500-520.

Florida, R. (2003) ‘Entrepreneurship, Creativity, and Regional Economic Growth’ in Hart, D. The Emergence of Entrepreneurship Policy: governance, Start-Ups, and Growth, Cambridge University Press, pp.39-64.

Freeman, C. (1982) The Economics of Industrial Innovation: 2nd Edition, London: Frances Pinter.

Frosch, K. H. (2011) ‘Workforce Age and Innovation: A Literature Survey’, International Journal of Management Reviews, 13, 414–430.

Forsman H. (2011) ‘Innovation capacity and innovation development in small enterprises. A comparison between the manufacturing and service sectors’, Research Policy 40(5), 739-750.

Foss, N.J. 2005. Strategy, economic organization, and the knowledge economy. The coordination of firms and resources. Oxford: Oxford University Press

Foss, N. J., Knudsen, C. and Montgomery, C. (1995) 'An Exploration of Common Ground: Integrating Evolutionary and Strategic Theories of the Firm' in Montgomery, C., ed. *Resource-Based and Evolutionary Theories of the Firm: Towards a Synthesis*, Boston, MA: Kluwer Academic, 1-16.

Gallié, E.-P. and Legros, D. (2012) 'Firms' human capital, R&D and innovation: a study on French firms', Empirical Economics, 43, 581-586.

Ganotakis, P. (2012) 'Founders' human capital and the performance of UK new technology based firms', Small Business Economics, 39(2), 495-515.

Grant, R. M. (1996) 'Toward a Knowledge-Based Theory of the Firm', Strategic Management Journal, 17, 109-122.

Griffith, R. Huergo, R., Crest, J. M. and Peters, B. (2006) ‘Innovation and productivity across four European countries’. Oxford Review of Economic Policy, 22(4), 483-498.

Guery, L. and Pendleton, A. (2014) ‘Do investments in human capital lead to employee share ownership? Evidence from French establishments’, Economic and Industrial Democracy, 1-25.

Hall, T. J., Lotti, F. and Mairesse, J. (2009) 'Innovation and productivity in SMEs: empirical evidence for Italy', Small Business Economics, 33(1), 13-33.

Heinonen, J. and Korvela, K. (2008) ‘How about measuring intrapreneurship?,

Herrera, H. and Sánchez-González, G. (2012) ‘Firm size and innovation policy, International’, Small Business Journal, 31(2), 137-155.

Hitt, M. A., Bierman, L. and Kochhar, R. (2001) 'Direct and Moderating Effects of Human Capital on Strategy and Performance in Professional Service Firms: A Resource-Based Perspective', Academy of Management, 44(1), 13-28.

Hoegl, H. and Proserpio, L (2004) ‘Team member proximity and teamwork in innovative projects’, Research Policy 33(8), 1153–1165.

Jaffe, A. B. and Le, T. (2015) ‘The impact of R&D subsidy on innovation: A study of New Zealand firms’. Muto Working Paper, 15-8.

Kato, M., Okamuro, H. and Honjo Y. (2015) 'Does Founders' Human Capital Matter for Innovation? Evidence from Japanese Start-ups' Journal of Small Business Management 2015 53(1), 114–128

Kemeny, T. (2014) 'Immigrant Diversity and Economic Performance in Cities', international regional Science Review, 1-45.

Lai, Y., Saridakis, G., Blackburn, R. and Johnstond, S. (2016) ' Are the HR responses of small firms different from large firms in times of recession?' Journal of Business Venturing, 31, 113-133.

Lenihan, H. (2011) 'Enterprise policy evaluation: Is there a 'new' way of doing it?' Evaluation and Program Planning, 34 (4), 323-332.

Lockett, A. and Thompson, S. (2001) 'The resource-based view and economics', Journal of Management, 27, 723-754.

Lorenz, E. (2013) Innovation, Work Organization, and Systems of Social Protection' in, Fagerberg, J. et al., Innovation Studies: Evolution and future challenges, Oxford University Press: Oxford. pp71-89.

Lorenz E. and Lundvall, B-A. (2011) Accounting for Creativity in the European Union: A multi-level analysis of individual competence, labour market structure, and systems of education and training', Cambridge Journal of Economics 35, 269-294.

Malmberg, A. and Maskell, P. (2002) 'The Elusive Concept of Localization Economies: Towards a Knowledge-Based Theory of Spatial Clustering', Environment and Planning A, 34(3), 429-449.

Martins, E.C. and Terblanche F. (2003) Building organisational culture that stimulates creativity and innovation', European Journal of Innovation Management, 6(1), 64-74.

McGuirk, H. and Jordan, D. (2012) 'Local labour market Diversity and Business Innovation: Evidence from Irish manufacturing Businesses', European Planning Studies, 20(12), 1945-1960.

McGuirk, H., Lenihan, H. and Hart, M. (2015) 'Measuring the impact of Innovative Human Capital on small firms' propensity to innovate', Research Policy 44(4), 965-976..

Manez J.A., Rochina-Barrachina, E., Sanchis-Llopis, A. Sochis-Llopis J. (2015) 'The determinants of R&D persistence in SMEs', Small Business Economics, 44, 505-528.

Montalvo, C. (2006) 'What triggers change and innovation?', Technovation, 26(3), 312-323.

Naz, A., Niebuhr, A. and Peters, J. C. (2015) What's behind the disparities in firm innovation rates across regions? Evidence on composition and context effects' Annals Regional Science, 55, 131–156.

Nelson, R.B. (1991) Why Do Firms Differ, and How Does it Matter? Strategic Management Journal 12, 61-74.

Nielsen, B.B. and Nielsen, S. (2009) 'Learning and Innovation in International Strategic Alliances: An Empirical Test of the Role of Trust and Tacitness', Journal of Management Studies, 46(6) 1031-1056

Nielsen, P., Nielsen, R., Bamberger, S., et al. (2012) 'Capabilities for innovation: the Nordic model and employee participation'. Nordic Journal of Working Life Studies, 2(4), 85-115.

Ottaviano, G. and Peri, G. (2006) 'The economic value of cultural diversity: evidence

from US cities'. Journal of Economic Geography 6, 9–44.
OECD (2014) OECD Science, Technology and Industry Outlook, OECD Publications.
Penrose, E. (1995) The Theory of the Growth of the Firm, 3rd ed., New York: Oxford University Press.
Pinchott, G. (1986) Intrapreneuring. New York: Harper & Row.

Ployhart, R. E. and Moliterno T. P. (2011) 'Emergence of the Human Capital resource: A Multilevel Model', Academy of Management Review 36(1), 127-150.
Radas, S' and Božić, L. (2009) 'The antecedents of SME innovativeness in an emerging transition economy', Technovation 29(6-7)–450.

Robson, P. J. A., Akuetteh, C. K., Westhead, P. and Wright, M. (2012) 'Innovative opportunity pursuit, human capital and business ownership experience in an emerging region: evidence from Ghana', Small Business Economics, 39(3), 603-625.
Rodriguez, A., Dahlman, C. and Salmi, J. (2008) Knowledge and Innovation for competitiveness in Brazil, Washington: The World Bank.
Rogers, M. (2004) 'Networks, Firm Size and Innovation', Small Business Economics, 22(2), 141-153.
Roper, S., Youtic, J., Shapira, P. and Fernandez-Ribas, A. (2010) 'Knowledge, Capabilities and manufacturing Innovation: A USA-Europe Comparison', Regional Studies, 44(3), 253-279.
Rothwell R. (1989) 'Small Firms, Innovation and Industrial change' Small Business Economics 1(1), 51-64.
Ruppel, C. P. and Harrington, S. J. (2000) 'The Relationship of Communication, Ethical Work Climate, and Trust to Commitment and Innovation', Journal of Business Ethics, 25(4), 313-328.
Schumpeter, J. (1934) The Theory of Economic Development, New Brunswick: Transaction Publishers.
Schumpeter, J. (1942) Capitalism, Socialism and Democracy, New York: Harper.
Seshadri, DVR. And Tripathy, A. (2006) 'Innovation through Intrapreneurship: The Road Less Travelled', VIKALPA, 31(1).
Shipton, H., West, M. A., Parkes, C. L., Dawson, J. F. and Patterson, M. G. (2006) 'When promoting positive feelings pays', European Journal of Work and Organizational Psychology, 15(4), 404-430.
Silverberg, G., Dosi, G. and Orsenigo, L. (1988) 'Innovation, Diversity and Diffusion: A Self-Organisation Model', The Economic Journal, 98(393), 1032-1054.
Teece, D. J. (1980) 'The Diffusion of an Administrative Innovation', Management Science, 26(5), 464-470.
Teece, D.J. and Pisano, G. (1994) 'The Dynamic Capabilities of Firms: An Introduction', Industry & Corporate Change, 3 (3), 537-556.

Van derSljde, P., Veenker, S. and During, W. (2013) 'Intrapreneurship in SMEs: About the Role of Management and R&D', European Journal of Business and Social Sciences, 1(11), 24-30.
Vaona, A and Pianta, M. (2008) 'Firm Size and Innovation in European Manufacturing' Small Business Economics, 30(3), 283-299

von Krogh, G. and Wallin, M. W. (2011) 'The Firm, Human Capital, and Knowledge Creation' in Burton-Jones, A. and Spender, J. C., eds., The Oxford Handbook of Human Capital, Oxford: Oxford University Press, pp.261-286.
Williams, L.K. and McGuire, S.J. (2010) 'Economic creativity and innovation implementation: the Entrepreneurial drivers of growth? Evidence from 63 countries', Small Business Economics 34, 391-412.
Wu C., Parker S. K. de Jong J (2014) 'Need for Cognition as an Antecedent of Individual Innovation Behavior' University of Western Australia Journal of Management, 40(6), 1511–1534.
Swann, P. (2009) The Economics of Innovation, Cheltenham UK: Edward Elgar.