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Abstract

This paper analyses the relationship between firm's perception of market risk and engagement in innovation. We conceptualise this relationship by integrating insights from the management literature on innovation barriers with those derived from the international business and economic geography perspectives on the interplay of ownership and location advantages. By exploiting a firm-level panel dataset based on the UK Innovation Survey for the period 2002-2008, we test the relationship between perception of market risk and innovation behaviour in relation to firm ownership – i.e. multinational enterprises (MNEs) versus single domestic enterprises – and location – across regional contexts characterised by different degrees of technological dynamism. Our main results show that ownership advantages operate as a moderator by fundamentally affecting the direction of the relationship: whilst MNEs react positively to risk perception, single domestic firms reduce their innovation engagement as a strategy to cope with market uncertainty. Yet, ownership advantages play a pivotal role only in relatively inert or stable contexts, as in technologically dynamic regions differences between domestic firms and MNEs disappear.

Keywords: Risk perception, Innovation behaviour, Ownership and Location advantages, Community Innovation Survey, UK Regions.

JEL Codes: F23, O31, R11

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1. Introduction

Multinational Enterprises (MNEs) are considered the largest contributors to innovation and technology generation, transfer and diffusion (e.g. Cantwell, 1989). The rationale behind their pivotal role in the global economy has been analysed in various and interrelated disciplines including management studies, international business and economic geography (e.g. Caves, 1974; Dunning, 1980; Oulton, 1988; Cantwell, 1989; Iammarino and McCann, 2013).

The management research, in particular, has suggested that firms' attitude towards risk is a key determinant of their successful innovation efforts. According to this view, MNEs, particularly when originating from advanced innovation systems, display on average a lower degree of risk-aversion and a higher propensity to consider failure as a fertile ground for learning and enhancing the potential for innovation achievement (Ferriani et al., 2008). This stronger attitude to engage in more (and riskier) innovative projects in turn contributes to boost their innovation outcomes (Oulton, 1988).

This paper investigates the relation between risk perception and innovation within the context of the classic Ownership-Internalization-Location (OLI) paradigm (Dunning, 1977; 1980; 2000), which offers a comprehensive framework for the analysis of MNE strategic behaviours. More in detail, it aims at exploring the role of ownership (O-) and location (L-) advantages as key moderator factors, thus analysing whether the relationship between risk perception and innovation is affected by the firm ownership status – qualified in terms of "multinationality" or being part of a MNE group – and its location – across subnational regions characterised by a different degree of technological dynamism.

To this scope, the paper postulates that the extent to which firms react to their perception of risk by engaging in innovation depends on their specific ownership advantages in the form of technological, organisational and marketing capabilities – which the international business

literature assumes to be higher in the case of MNEs when compared to uni-national domestic firms (e.g. Caves, 1974; Dunning, 1980; Cantwell, 1989) – and on the characteristics of their host technological environment (e.g. Cantwell and Piscitello, 2002; Cantwell and Iammarino, 2003). The former moderating relation rests on the fact that larger technological and organisational competences enhance the opportunities for risk-spreading management practices across a wider portfolio of innovation projects (e.g. Dachs and Peters, 2012). The latter moderation effect relies on the observation that geographical location does not only affect the way in which firms exploit their ownership advantages – which are contingent on the differentiation of regional innovation systems and technological environments (e.g. McCann, 2016) – but has a bearing also on how firm's perception of risk is capitalized into innovation by affecting the balance between threats and opportunities (Ang, 2008).

From this conceptual framework, we derive a set of testable hypotheses and validate them empirically by assembling a new panel dataset for 4050 companies sampled in the UK Innovation Survey (UKIS) during the period 2002-2008 – never used in previous research. We complement UKIS data with information from the Census of UK enterprises, also known as Business Structural Database (BSD), to account for the degree of technological dynamism – or turbulence – firms face in their operational environment.

Our findings offer interesting insights: first, and in line with previous empirical literature on innovation management, firm awareness of market risk is positively associated with the probability to engage in innovation activities. Second, O-advantages operate as a crucial moderator by affecting the direction of the relationship between risk perception and innovation: whilst MNEs, both foreign- and UK-owned, react positively to market risk, single domestic firms reduce their innovation engagement as a strategy to cope with higher demand uncertainty. Third, by considering the concurrent role of O- and L-advantages, we find that the former positively

moderate the relationship only in relatively inert or stable regions, as in more technologically dynamic contexts differences in the reaction to risk between single uni-national firms and MNEs disappear. This ultimately suggests that the relevance of O-advantages in the relationship of interest is contingent upon L-advantages, that is, the characteristics of the host regional innovation system.

This study aims at contributing conceptually and empirically to the literature on firm innovation strategies, and related risks and barriers, and to the ongoing adaptation of the 'classical' MNE advantages in international business – i.e. the OLI paradigm – to more fine-grained geographical lenses. On the conceptual side, bridging different strands of literature helps clarify the still understudied interaction between O- and L-advantages at the micro (firm) and meso (subnational) levels (Iammarino and McCann, 2013). On the empirical side, the results are robust to several limitations that apply to previous research, including the role of unobserved firm-specific characteristics and broader endogeneity concerns.

The paper is organised in 6 sections. The following Section 2 provides the conceptual framework from which we derive our main hypotheses; Section 3 describes the data and presents some descriptive evidence; methodology, endogeneity concerns and strategies for addressing them are reported in Section 4, whilst Section 5 discusses the results; conclusions and implications are presented in the final Section 6.

2. Conceptual background and hypotheses

2.1 Firm risk perception and innovation behaviour (Hp 1)

The relationship between risk perception and innovation behaviour at the firm level has been investigated in both management and marketing sciences (e.g. Katila and Shane, 2005; Ferriani et al., 2008), and innovation studies (e.g. Arundel, 1997; Mohnen and Röller, 2005; Mancusi and

Vezzulli, 2010). The main rationale in management studies is that risky and uncertain market conditions impose objective obstacles to firms' investments in new knowledge, especially for specific typologies of business organisations in terms of size and market of reference (Katila and Shane, 2005).[1] Concurrently, however, risk and uncertainty open up to firms new opportunities, which in turn provide incentives to explore new ventures and potential to learn from own and others' failures (e.g. Miner et al., 1999; Denrell, 2003). In this context, because innovation is almost invariably punctuated by setbacks and failures (Ferriani et al., 2008), and failure can be highly valuable for learning (Miner et al., 1999), firms' capacity to keep climbing the innovation ladder is seen as fundamentally related to a proactive attitude to risk. Both past success – which leads to risk-taking behaviours (therefore investments in innovation) – and failure – which is a source for learning – are interpreted as motivations to change, rather than enablers of inertia as a defensive strategy under uncertainty.

Within this framework, the conceptual model elaborated by Sitkin and Pablo (1992, 10) defines risk as "the extent to which there is uncertainty about whether potentially significant and/or disappointing outcomes of decisions will be realized". The model maintains that the characteristics of firms (or other organisations) do not directly impact on their reaction to risk but operate indirectly via the mechanisms of risk perception and propensity. In this context, firms' perceptions of, and propensity towards, risk are inherently a firm-specific dimension, and represent major predictors of how they approach the decision to undertake innovation investments.

[1] For instance, smaller firms are likely to perceive stronger barriers to innovation in wider and less competitive markets, since larger multi-plant enterprises are more likely to capitalize on the capabilities necessary to coordinate various complementary intra- and extra-firm knowledge sources (e.g. Tripsas, 1997; D'Este et al., 2012). On the other hand, large incumbent firms may be less prone to risk-taking because of organisational inertia, structured routines, or established core competencies that may limit their ability to adapt to environmental uncertainty (e.g. Nelson and Winter, 1982; Hannan and Freeman, 1984; Dougherty, 1992).

This argument has been fully incorporated in the large empirical literature on firms' perception of obstacles to innovation (see, for a review, D'Este et al., 2012), which has explicitly looked at the impact of such barriers – including risk perception – on firm propensity to innovate (e.g. Arundel, 1997; Tourigny and Le, 2004; Mohnen and Röller, 2005; Savignac, 2008; Mancusi and Vezzulli, 2010). The results of these studies – which are directly related to our empirical exercise here – broadly support the existence of a positive relation between risk perception and innovation behaviour, though serious concerns apply to the potential estimation bias associated to the presence of heterogeneous unobserved firm-specific factors (i.e. entrepreneurial attitude or assessment of market opportunities) and the simultaneous determination of the risk/obstacle perception and the decision to innovate (e.g. Mohen and Roller, 2005; Tiwari et al., 2007; Savignac, 2008; Mancusi and Vezzulli, 2010).

These different streams of management and innovation literature substantiate our first hypothesis, which establishes the nature of the main relationship here in object:

Hp 1: Perception of market risk is positively associated to firms' decisions to engage in innovation

2.2 The moderating role of O-advantages (Hp 2)

The importance of firms' ownership advantages has been seen as a pivotal explanation of MNE strategic behaviours in the classic eclectic Ownership-Location-Internalization (OLI) paradigm – originally formulated by John Dunning (e.g. 1988) and subsequently updated by Dunning himself (e.g., 2001, 2009) and others.[2] In this framework, MNEs own specific tangible and intangible assets relative to their domestic competitors, among which the possession of unique technological

[2] The OLI has provided the main analytical framework for examining the behaviour of multinational enterprises and its transformation over time. Theoretical and empirical contributions in a vast array of social sciences – i.e. from economics, to international business, managerial and sociological perspectives, and innovation studies – all subsumed in the OLI, have greatly advanced our understanding of the nature of O-advantages, and its growing connections and interactions with both internalization (e.g. Castellani and Zanfei, 2004, 2006) and location (e.g. Dunning, 1998) advantages.

competencies is arguably the most important. Such assets can be replicated easily across different locations, and the marginal cost of transferring them within intra-firm networks and across space is usually rather low. This rationale works simultaneously in favour of further accumulation of technological and organisational competence, providing inherent capabilities and skills through more effective learning in different functions (i.e. production, R&D, headquarters, marketing, logistic, etc.) and across places. In line with this argument, research has shown that, for firms belonging to MNE groups, failure to achieve the outcome of innovation efforts is far more likely to provide a fertile ground for learning and enhancing the potential for future success (Miner et al., 1999; Ferriani et al., 2008).

In line with this argument, the distinctive ownership advantages that make it possible for MNEs to establish integrated production and innovation networks of affiliates, as a means of building a sustainable competitive advantage based on advanced capabilities and dynamic improvements (e.g. Dunning and Narula, 1995; Zanfei, 2000; Frost, 2001; Veugelers and Cassiman, 2004), also heightens the probability that such firms exploit their possibilities of risk spreading across a wider portfolio of innovative projects to prosper in dynamic and risky environments (e.g. Hamel and Prahalad, 1985; Ghoshal, 1987; Kim et al., 1993).

We draw from this intuition to state our second hypothesis to be tested in the empirical exercise. In doing that, we also follow the forerunner intuition by Sitkin and Pablo (1992, 26) that "One possibility is to argue that the risk perception/risk behaviour relationship is contingent, in that hidden moderator variables alter the relationship between perceptions and behaviour" to qualify the role of O-advantages in the relation between risk and innovation. Thus, our second hypothesis is:

Hp 2: Ownership advantages (i.e. multinationality) moderate positively the relation between risk perception and firms' innovation behaviour.

2.3 L-advantages and the interaction between micro and meso characteristics (Hp 3 and Hp 4)

The conceptualization of the relation between risk perception and innovation in the context of the OLI paradigm needs also to take into account its evolution in response to the rapid changes in the global institutional and technological environment of the last decades, which have had important repercussions for the balance of the "three-legged stool" represented by the OLI (Dunning, 2009), thus affecting the nature of L-advantages and, as a consequence, its interaction with both ownership and internalisation (Iammarino and McCann, 2013).

In fact, although both international business and economics have long posited that the impact of firm-specific advantages is contingent upon the features of the host location (e.g. Dunning, 1980; Buckley, 1990; Erramilli et al., 1997; Anastassopoulos, 2003), the role of geography has generally been acknowledged at the macro level of the nation state. Instead, more recent evolutionary views of technological change and economic geography applied to firms' behaviour have paid growing attention to the role of *places* in the determination of both corporate performance and strategies (e.g. Beugelsdijk et al., 2010; Jenkins and Tallman, 2010; Mariotti, et al., 2010). This strand of research pairs with the intuition that the nature of the operational environment affects the balance of risks and opportunities to which firms are exposed (e.g. Hill and Rothaermel, 2003; Ang, 2008). Thus, the relationship between perceived risk and firms' behaviour cannot be properly understood without considering the set of opportunities and constraints firms face as a result of their technology environment (e.g. Nelson and Winter, 1982; Delios and Beamish, 1999; Shane, 2001). In more dynamic regional innovation systems, in fact, firms tend to respond to perceived risk by enhancing their innovative efforts, mainly because diversification and departure from the existing local knowledge base may spur the exploration of emerging opportunities and new markets, and the minimization of economic damages (e.g. Escribano et al., 2009). Conversely, technologically stable or inert environments, relatively more oriented toward exploitation,

refinement, and efficiency improvements, offer lower opportunities, making firms less prone to innovative ventures as a response to perceived economic risks.

This leads us to the following third hypothesis to be verified in the subsequent empirical investigation:

Hp 3: Location advantages moderate the relation between risk perception and firms' innovation behaviour.

Hypothesis 3 assumes that the relationship between risk awareness and innovation is moderated (for all types of firms) by their geographical context, insofar as more technologically dynamic regions offer higher payoffs from risk-taking behaviours, thus stimulating greater innovation efforts. We make a step forward in our conceptualization of the role of L-advantages by acknowledging also their interplay with O-advantages in shaping the relationship between risk perception and firms' innovative behaviour. In this context, O-advantages are increasingly viewed as reliant on the ability to explore and select among a wide range of knowledge and quality sources, highly localized and specific to regional and local innovation systems (e.g. Cantwell and Piscitello, 2002, 2005; Cantwell and Iammarino, 2003; Bathelt et al., 2004; McCann and Mudambi, 2005; Maskell et al., 2006; Alcácer and Chung, 2007; Malecki, 2010). Hence, L-advantages matter both *per se* – by shaping the set of incentives in terms of balance between risks and opportunities firms face in their business environment (Gordon and McCann, 2005; Ang, 2008) – and in conjunction with firm-level capabilities and O-advantages (e.g. Maskell and Malmberg, 1999; Boschma, 2004).[3]

[3] It is worth noting that, to our knowledge, very few studies have taken into consideration the relevance of different geographical contexts in firms' perception of obstacles and innovation engagement, and most importantly how firm- and context-specific characteristics interact in shaping such relationship. Among these contributions Iammarino et al. (2009) show that, overall, firms located in the macro-regions of Northern and Central Italy tend significantly less to perceive as relevant obstacles to innovation than firms located in the South. Interestingly, they also show that geographical specificities in the perception of the obstacles to innovation characterise only single domestic firms.

We propose that the extent to which O-advantages in terms of multinationality represent key firm-specific (micro-level) advantages affecting the way perceived risk translate into firms' innovative strategies vary across regional (meso-level) contexts, insofar as such advantages exist in relation to the specific features of the host location (Erramilli, 1997). Hypothesis four reads as follows:

Hp4: The impact of Ownership advantages on the relationship between risk perception and innovation behaviour is contingent upon Location advantages.

3. Data

3.1 Data and main variables' construction

The analysis exploits a novel database that makes use of a combination of micro-data at the firm level. The main source is the UK Innovation Survey (UKIS), the most comprehensive data sources on business innovation in the country, which represents the UK's contribution to the wider European Community Innovation Survey (CIS). The UKIS is conducted biennially and it provides information on, among other aspects, innovative activities and performance, innovation-related investments, knowledge sources, cooperation for and obstacles to innovation. It is based on a representative sample of businesses with more than 10 employees, stratified across sectors of activity – both manufacturing and services – as defined by the Standard Industrial Classification of Economic Activities (SIC 2003), and regions as defined by the Governmental Office Regions (GORs) level in England, Scotland, Wales and Northern Ireland.

The data used in this study come from the balanced panel provided by the UK Office of National Statistics (ONS) and constructed by merging three waves of the UKIS, covering the period 2002-2008 (2002-2004; 2004-2006; 2006-2008). The sample includes 4,050 business firms participating

as respondents in all three consecutive waves:[4] of these, about 64% is part of a UK-based MNE group, including both foreign- and UK-owned,[5] whilst the remaining sampled firms are single domestic businesses. We use the information on the ownership status of the firm to test for the relevance of O-advantages when analysing the relation between innovation behaviour and perception of market risk. To this scope, we construct a dummy variable taking value 1 if the firm is classified as a single domestic business and 0 otherwise (*Domestic*).

Firms' innovative behaviours are measured by adopting as dependent variable the category of *innovation-active* firms, defined by the ONS as those businesses that have engaged in any of the following activities (see also D'Este et al., 2012; Crescenzi et al., 2015):[6]

- Introduction of a new or significantly improved product (good or service) or process;
- Innovation projects not yet completed, or abandoned;
- Expenditure in areas such as: intramural (in-house) R&D; acquisition of R&D (extra-mural); acquisition of machinery, equipment or software; acquisition of external knowledge; training; all forms of design; marketing and advertising.

[4] Sample statistics comparing key variables for the panel dataset used in this study with data from each UKIS original wave are reported in Appendix A (Table A.1) without evidence of substantial differences in the sample composition.

[5] Our data allow identifying firms that are part of a multinational group: however, we do not have the possibility to distinguish between actual branches or affiliates as no information is available on the percentage owned. We are able to distinguish between foreign- and UK-owned MNEs but, due to the large number of missing values, the information on the nationality of ownership could not be exploited here.

[6] Information on product innovation is recovered from the following question: "During the 3 year period, did this business introduce new or significantly improved goods; new or significantly improved services?"; process innovation refers to the following question: "During the 3 year period, did this business introduce any new or significantly improved processes for producing or supplying goods or services?"; innovation project not yet completed, or abandoned comes from: "During the 3 year period, did your enterprise have any projects to develop or introduce new or significantly improved products (goods or services) or processes that were abandoned or not yet completed?"; innovation expenditures are derived from the question "During the 3 year period, did this business engage in the following innovation related activities?".

This classification of innovation-active firms assumes a broad perspective by taking into account both output- and input-based definitions of innovative behaviours, including firms with successfully completed innovation projects as well as those that have undertaken investments in innovation not yet completed or abandoned. As such, the variable provides a comprehensive measure of engagement in innovation activities independently on their actual outcome. This is key to our analysis as we build our conceptual framework assuming that risk perception is a predictor of the probability of firms to engage in innovation rather than of their probability of success. The dependent variable (*Innovation-active*) is constructed as a dummy that takes value 1 if a firm is defined as innovation-active in any of the three waves during the period 2002-2008, and 0 otherwise.

The survey provides also information on the major obstacles to innovation, a section of the CIS questionnaire replied by all firms independently on whether they engaged or not in innovative activities. Firms are asked to report whether they have experienced any of the listed types of obstacles and, if so, to assess their importance.[7] This section of the questionnaire is used to construct the main regressor of interest in our analysis (*Perceived risk*), which provides information of firms' risk perception on a Likert scale that goes from 0 to 6.[8]

[7] Information on the obstacles to innovation comes from the following question: "During the 3 years' period, how important were the following factors in constraining innovation activities?". Beyond those barriers used to construct our independent variable (excessive perceived economic risk and uncertainty of the demand for innovative products or services), the other listed in the CIS are: difficulties in financing innovation investments deriving from their excessive cost or from the lack of appropriate financial resources, scarcity of qualified personnel, lack of information on available technologies, and presence of incumbent firms with high market power. We use also these variables in our empirical estimation, see Section 4 below.

[8] The variable is constructed calculating the sum between the values reported for the categories of "Excessive perceived economic risks" and/or "Uncertain demand for innovative goods or services". Firms evaluate each single category on a Likert scale that goes from 0 (not applicable) to 3 (very important). Therefore, if for instance the firm rates both uncertain demand and excessive perceived economic risk equal to 0, the summative variable "Perceived risk" will be equal to 0; if the firm rates the former category equal to 1 and the latter equal to 0, "Perceived Risk" will take value 1 and so on up to the case in which the firm rates both categories equal to 3 such that the summative variable takes value 6. This discrete version makes it possible to fully exploit the information in the data. Results

UKIS data are also used to recover information on the share of skilled employees, i.e. those with a degree qualification; industrial sector of activity defined at 2 digits level; and GOR region.

Together with the UKIS we employ data from the Business Structural Database (BSD), which represents the census of UK enterprises covering almost 99% of all firms in the country. Data from the BSD are available since 1997, they are geo-referenced up to the postcode level and provide detailed information on employment, turnover and sector of activity. We use BSD data to define an indicator of technological dynamism at the regional level based on employment fluctuations within each UKIS wave in High- and Medium/High-Tech Manufacturing and Knowledge Intensive Services (KIS).[9] This indicator (*Regional dynamism*) is in turn used to test for the relevance of L-advantages in the relationship between firms' innovative behaviour and perception of market risk. In other words, we look at such a relationship through the characteristics, in terms of degree of technological dynamism, of the regional environments in which firms operate.

A complete list of the variables included in the analysis is reported in Appendix A (Table A.2).

3.2 Descriptive statistics and unconditional correlations

A descriptive analysis of our sample shows that about 67% of firms is defined as innovation-active, that is firms that have engaged in any completed, ongoing or abandoned innovation project or investment over the period 2002-2008. The share of innovation-active rises to 69.2% in the case of businesses part of a multinational group, while it decreases to 62.8% for single domestic firms (Table 1). As expected, MNEs tend to score higher in all types of innovation-related activities: our

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remain consistent also when the variable is constructed as a dummy that takes value 1 if the firm rates 2 or 3 both components and 0 otherwise.

[9] The definition of manufacturing sectors by technology intensity is derived from the OECD (https://www.oecd.org/sti/ind/48350231.pdf), whilst KIS definition is taken from the EU Commission (https://ec.europa.eu/research/innovation-union/pdf/knowledge_intensive_business_services_in_europe_2011.pdf) as also employed by Schnabl and Zenker (2013). From the KIS sample we excluded public sector services (Education, Health and Social Work, Recreational, Cultural and Sporting Activities).

data, while confirming MNEs' better performance in terms of both completed and ongoing innovation projects, also highlight that they are more likely to abandon these ventures (Figure 1). This suggests that MNEs are overall both more innovative and prone to sort into challenging innovation projects. Relatedly, the share of firms perceiving risk and uncertainty in market conditions as key barriers to innovation is higher for innovation-active firms and for MNEs (Table 1),[10] confirming the importance attributed to innovation constraints (UK Data Archive, 2008).[11] Consistently, among innovation-inactive firms the share of those declaring to have been affected by market risk is significantly higher for single domestic firms than for MNEs. This descriptive evidence suggests that (a) the perception of market risk is positively associated with increasing innovation efforts, and (b) firms' innovative behaviour under risky market conditions is affected by their ownership status, with a higher share of innovation-inactive single domestic firms perceiving risk as an actual *deterrent barrier* to innovation, and a higher proportion of MNE groups, both national and foreign, reporting *revealed barriers* experienced while engaging in innovation processes (see also D'Este et al., 2012).

[Include Table 1 and Figure 1 here]

To investigate the relevance of L-advantages, our measure of regional technological dynamism is based on a shift-share approach that attributes employment fluctuations within each wave in High- and Medium/High-Tech Manufacturing and KIS to each region based on its industry specialization in 1998. Put differently, we assume that each region is affected by fluctuations in employment as if its industrial specialization had remained unchanged since 1998. The variable takes the following form:

[10] Descriptive statistics are presented measuring perceived risk as a dummy that takes value 1 if firms rate equal to 2 or 3 both categories of obstacles to innovation ("Excessive perceived economic risks" and/or "Uncertain demand for innovative goods or services") and 0 otherwise.

[11] UK Data Archive Study Number 6699.

$$Regional\ dynamism_r = \sum_{r,t} Employment_{r,z,1998} \times Employment\ fluctuations_{z,t} \quad (1)$$

Thus, we measure specialization in 1998 by means of employment shares by industry z and region r. This will act as a factor loading the impact of employment fluctuations (captured by means of the variation within each wave t of employment by industry z at the national level) to each region. This interaction is then collapsed by summing up over regions and waves. This makes it possible to exploit the industry dimension to measure technological dynamism, or turbulence, at the regional level, while also satisfying the sound exogeneity conditions of the traditional Bartik's (1992) approach. In fact, by attributing employment fluctuations to each region on the basis of its pre-existing industry specialization, we factor out the endogeneous evolution of the regional industry mix. Table 2 reports the value of our measure of Regional dynamism across regions. On average, and not surprisingly, over the whole period 2002-2008 London and the South East turn out to be the most dynamic areas, while the Midlands (both East and West), Scotland and Northern Ireland are characterised by more stable/inert environments. Notably, none of our regions shows negative employment fluctuations in high-technology and knowledge-intensive industries. Table 2 also reports the number of innovation-active firms by region and the share of those reporting high perceived risk. Interestingly, the more dynamic regions do not turn out to be those where the correlation between firms' innovation behaviour and perceived market risk is particularly significant. One remarkable example is the case of the South East, with high shares of innovation-active firms, high technological dynamism but low levels of risk perception.

[Include Table 2 here]

From the conceptual framework in Section 2, O- and L-advantages do interact in affecting our relation of interest: that is, the role of O-advantages as a key moderator of the relation between innovation behaviour and perceived risk is influenced by contextual conditions. Preliminary evidence in this respect is provided by Figure 2, a cartographic illustration of the spatial

distribution of innovation-active firms by ownership. Innovation-active MNEs are indeed mostly concentrated in the Midlands and the South East; for single domestic enterprises the share of innovation-active is significantly lower in leading regions such as the South East, while it remains in line with MNE figures in the West Midlands, and is significantly higher in the South West and Northern Ireland. These spatial patterns provide support to previous findings, pointing out that the spatial distribution of MNEs tends to conform to a hierarchy of regional innovation systems in the UK (e.g. Cantwell and Iammarino, 2000). In Figure 3, we further explore the unconditional correlation between firm's innovative behaviour and perceived market risk by taking into account differences in both O- and L-advantages. Stable/inert environments are defined as those with a level of technological dynamism below the median value, while dynamic regions are those with the indicator in the upper 50% of the distribution. Interestingly, whereas in fast-changing regions higher perceived risk is associated with a smaller gap in innovative performance between MNEs and domestic firms, the opposite is true in more sluggish environments, where the differential between the two groups of firms is significantly larger. This preliminary evidence indicates that L-advantages influence the role of O-advantages as key driver of the relation between innovation behaviour and perceived market risk.

[Include Figure 3 here]

4. Methodology

4.1 The model

The analysis is based on a two ways panel data estimation approach that makes it possible to include both time and firm level dummies. The estimation equation takes the following form:

$$Innovation\ active_{itr} = \alpha_i + \delta_t + \beta_1 Perceived\ risk_{it} + \beta x_{it} + \varepsilon_{itr} \quad (2)$$

Where the subscripts *i, t* and *r* refer to firm, wave and region respectively. $Innovation\ active_{itr}$ is the dependent variable constructed as a dummy that takes value 1 if the firm is innovation-active and 0 otherwise; $Perceived\ risk_{it}$ is the independent variable of interest which employs the self-reported level of perceived risk by firms; x_{it} is the (log) number of skilled employees; $\alpha_i$and δ_t are firm and time fixed effects respectively; and ε_{itr} is a well behaving error term. By adopting a two ways panel estimation approach we identify the impact of perceived market risk on innovation via the within-firm variation in innovative behaviour: that is, we look at whether changes over time in the firm's perception of risk affect its probability to engage in innovation activities.

The possibility to control for time invariant firm characteristics in equation 2 is a crucial advantage over previous research.[12] Perceived market risk as a key obstacle to innovation may correlate with unobserved firms' characteristics and therefore introduce a bias into the estimation.

To test for the role of ownership and location advantages in the relation of interest we introduce in equation (2) two interactions terms. First, we interact a variable labelled *Domestic* – a dummy that takes value 1 if a firm is a single domestic enterprise and 0 otherwise – with our main regressor of interest. This allows for identifying whether differences in ownership status moderate the relation between firms' innovation behaviour and perceived risk. It is important to note that firms' heterogeneity in terms of ownership structure is a time invariant firm level characteristic. For identification purposes, the component of the interaction referring to the variable *Domestic* is

[12] It should be noted that equation 2 has been estimated using a linear probability model (LPM). This is because the inclusion of a large set of dummies to control for time invariant firm level characteristics makes it difficult for standard nonlinear estimation techniques based on maximum likelihood estimation approaches to converge. Checks using the xtlogit routine, which allows controlling for firm fixed effects, are reported in Table 5: the xtlogit command, however, drops all observations without within-group variance of the dependent variable implying a significant reduction in the observations' number. The choice to rely on LPM techniques as preferred estimation approach also responds to endogeneity concerns. In fact, two-stage techniques for tackling endogeneity bases (see section 4.2 below) cannot be applied in a straightforward manner in the context of Maximum Likelihood (ML) or Control Function (CF) approaches. In case of any misspecification of the first stage the 2SLS approach would lose efficiency, while the ML or CF estimators would become inconsistent (Lewbel et al., 2012). For robustness, we also perform the estimation using non-linear techniques. Results, which are reported in Table A.3 (column 1), confirm our main findings.

included in equation (2) by means of firm level fixed effects. Second, we include another interaction term between our main regressor and the measure of location advantages, *Regional dynamism,* which is intended to capture the role played by contextual characteristics in influencing the relationship between innovation behaviour and perceived risk.

Our empirical framework makes it possible to test for hypotheses 1, 2 and 3. For testing hypothesis 4 we split the sample according to the level of regional technological dynamism, distinguishing firms located in regions with a level of dynamism below or above the median value of the variable distribution. Then, we re-estimate our baseline specification including the interaction between O-advantages and perceived risk across the two subsamples. This setting makes it possible to provide evidence on whether L-advantages influence the importance of L-advantages in the relationship of interest.

4.2 Endogeneity concerns

In investigating the relation between firms' innovative behaviour and perceived market risk a primary concern remains associated to the simultaneous relation between the two, which derives from the fact that firms are likely to concurrently assess the degree of risk and the decision to engage in innovation projects. This issue is exacerbated by the very nature of UKIS data, which cover a three-year period in each wave. To deal with this concern we employ instrumental variable techniques to introduce a shifter to firms' perception of risk, which is independent on whether or not they have been innovation-active over the three-year period corresponding to each UKIS wave. We look at the number of plant closures in the same region of the observed firm in the year after each survey period.[13] Firms that operate close to plant closure events may develop a greater awareness of risk (e.g. Clark and Wrigley, 1997). In addition, as we focus on plant closures in the

[13] To recover information on plant closure we use BSD data providing information on basic features, entry and exit for the universe of UK firms. As we do not have information for the year 2009 we restrict the analysis to the first two waves of UKIS.

year of the actual administration of the survey, such events are likely to exogenously increase the level of risk alleged by the firm at the point in which they were asked to fulfil the survey, independently on whether they engaged in any innovation activity in the preceding period. As our instrument might correlate with unobserved industry and regional trends such as to break the exclusion restrictions, we also re-run the 2SLS estimation controlling for the degree of regional technological dynamism.

5. Results

5.1 O- and L-advantages, innovation and risk perception

Results for the baseline specification estimated following equation (2) are presented in Table 3. Column 1 shows a positive and statistically significant correlation at 1% level between perceived risk and the probability of firms to be innovation-active. A one point increase in the perception of risk increases the probability of firms to carry out completed, ongoing, or abandoned innovation projects by 5%. This evidence suggests that risk awareness stimulates firms to invest in innovation, thus supporting hypothesis Hp1, as in the majority of previous analyses.

Column 2 includes the interaction term between the indicator for ownership advantages – i.e. the dummy for single domestic firms – and our regressor of interest to test hypothesis Hp2. The interaction term turns out to be negative and significantly correlated to innovation, while the baseline regressor for perceived risk remains positive and statistically significant. This finding points to a substantial heterogeneity across types of firms in the way in which risk perception shapes their innovative behaviour: whereas single domestic firms seem to reduce their innovative efforts in the presence of uncertainty, the positive relationship between risk and innovation is driven by the behaviour of MNEs. Overall, and in line with hypothesis Hp2, this finding supports the view that O-specific advantages associated to 'multinationality' moderates the relationship between the two main variables of interest. Column 3 introduces our proxy for L-advantages, the

indicator of regional technological dynamism, whose coefficient is negative and does not significantly impact on firms' engagement in innovation. Column 4 considers the second interaction term between the regional technological dynamism and the regressor for risk perception. Although positive, the interaction term is not statistically significant suggesting that, over the whole sample of firms, L-advantages do not moderate the relation between innovation and risk perception. This result does not support hypothesis Hp3. In this complete specification, the main relation of interest remains positive and statistically significant: an increase of one point in the Likert scale that measures risk perception increases by 12% the probability of firm investments in innovation.[14]

[Include Table 3 here]

5.2 L-advantages and the vulnerability of regions

Our baseline results suggest that MNEs are on average less risk adverse and more prone to invest in innovation activities independently on their outcome (e.g. Dachs and Peters, 2012). This behaviour is justified in the light of the distinctive ownership advantages associated to 'multinationality'. On the other hand, location advantages per se do not seem to influence the relation between innovation and risk perception. However, our conceptual framework also indicates that L-advantages may affect the way in which O-advantages channel the relationship under study.

To test whether the interplay between O- and L-advantages matters, we re-estimate the specification that includes the interaction between the firm ownership status and the variable of perceived risk (that reported in column 2 of Table 3) over the subsamples of firms located in

[14] To dig further into the nature of firms' O-advantages we also split the MNE sample between UK- and foreign-owned MNEs. Results reported in Table A.3 (column 2) suggest that the role of O-advantages associated to "multinationality" as a moderator of the relation between innovation and risks remain consistent independently on the nationality of ownership.

regions characterized by a level of technological dynamism either above or below the median value. Results presented in Table 4 show that the correlation between firms' innovative behaviour and perceived risk is positive and statistically significant in all regions. However, while the significant and negative effect of risk perception on domestic enterprises' innovativeness relative to MNEs persists in stable environments, it disappears in more dynamic regions.[15] This finding provides support for hypothesis Hp4: in dynamic environments, the innovative gap between MNEs and domestic firms is insignificant, indicating that L-advantages play a key role in influencing the effect of O-advantages.[16]

[Include Table 4 here]

5.3 Robustness checks

We perform a number of robustness checks on our main results. In Table 5 we control for other typologies of obstacles to innovation. From the UKIS micro data we are able to identify four alternative categories of obstacles, which may potentially represent relevant omitted variables correlated with perceived market risk. Column 1 includes a control for the lack of qualified

[15] It may be argued that these results reflect, at least partly, the fact that firms' location choices are endogenous to their ownership status, and in particular that MNEs are more likely to locate in 'higher order' regions (Cantwell and Iammarino, 2001). In order to account for the effect of this potential selection bias we replicate our estimates on the two subsamples by eliminating all firms in the most dynamic areas of the country (i.e. London and the South East). Results reported in Table A.3 (columns 3 and 4) show a remarkable consistency with those reported in Table 4.

[16] It may also be argued that, differences in L-advantages do not just affect the probability of firms to engage in innovation projects but also their innovation strategy. For instance, firms operating in more dynamic environments are also more likely to perform exploration strategies - i.e. to rely on external sources of knowledge - together with the exploitation of their internal sources of knowledge (Raisch and Birkinshaw, 2008). To check for this we construct the dependent variable "exploration" using data from the UKIS on the relevance of different information sources for innovation. Firms are asked to rate on a scale from 0 (not important) to 3 (utmost importance) the following sources: internal sources, market sources (including suppliers, clients and customers, competitors, consultants and commercial labs) and institutional sources (including universities and Government and public R&D institutes). The variable takes value 1 if the firm rates 2 or 3 market and/or institutional sources of information and 0 otherwise. Then, we run a similar estimation to that presented in Table 5 using "exploration" as a dependent variable. Results reported in Table A.4 (columns 4 and 5) show that in stable/inert regions MNEs differ substantially from domestic firms in terms of their innovation strategies, with the latter devoting limited resources to exploration. This difference reduces substantially in fast-changing environments where domestic enterprises behave more closely to MNEs. This result suggests that location advantage influence the role of ownership also with respect to the innovation strategy firms employ in response to perceived risk.

personnel: single domestic enterprises, when compared to large MNEs, may lack the expertise to develop innovation or the resources necessary to hire specific professional profiles. Column 2 controls for the role of information asymmetry with respect to technological or market factors. Column 3 gives account of market structure, in terms of presence of large incumbents, as a key barrier to innovation, whilst column 4 controls for differences in financial constraints. Finally, in column 5 all innovation barriers are simultaneously included in the equation (1): consistently with previous findings, most innovation barriers turn out to be statistically significant, but they do not affect the magnitude and significance level of the coefficients of our core variables. In model 5, only human capital and financial constraints seem to positively affect the firms' probability to engage in innovation activity.

[Include Table 5 here]

In Table 6 we split the sample between firms operating in high-tech manufacturing and KIS (column 1) from those active in low technology-intensive manufacturing and other services (column 2). The sectoral dimension plays, in fact, a relevant role as firms operating in technology- or knowledge-intensive industries are likely to develop a higher sensitivity to both emerging opportunities and risks (Ang, 2008). While the positive correlation between perceived risk and innovation persists in both samples, the heterogeneous effect associated to firm's ownership status emerges only for the sample of firms in low-tech industries. Consistently with previous findings, this evidence confirms that differences in technological regimes shift firms' incentives to engage in risky innovation projects (e.g. Nelson and Winter, 1982; Dosi, 1988; Delios and Beamish, 1999). In columns 3 to 5, we progressively include controls for area trends, industry trends and both. This last specification, computationally very demanding, fully controls for any unobserved regional and industry trends that may affect the innovative behaviour of firms. Our key findings remain substantially unchanged: risk perception is positively correlated to engagement in

innovation, though this result is mainly driven by MNEs. L-advantages instead do not seem to moderate the relation between innovation and risk perception.

[Include Table 6 here]

Finally, Table 7 displays additional controls. We first check for the consistency of our results against endogeneity concerns which, as acknowledged by existing research, may affect the estimates of the variable Risk perception. Column 2 (upper panel) reports the second stage results from a 2SLS estimation that employs the instrumental variable described in section 4.2, while column 1 reports the baseline results on the reduced sample for comparison.[17] The corresponding first stage is reported in column 2 (lower panel). The IV estimates confirm the positive and statistically significant relation between perceived market risk and firm's innovative behavior. Most importantly, the first stage confirms the strength of our instrument. Plant closure is, as expected, negatively and significantly correlated to the instrumented variable at 1% level, and the F statistics for the first stage is above the conventional value of ten popularised by Staiger and Stock (2002) and generally consistent with the Stock and Yogo (2005) threshold values. The size of the coefficient is larger with respect to the baseline estimates reported in Table 3. Yet, as standard errors are significantly higher, this likely reflects the lack of efficiency of the 2SLS routine with respect to the OLS. Finally, column 3 reports the second and first stages (upper and bottom panel respectively) corresponding to the 2SLS estimation performed controlling for the measure of regional technological dynamism to make sure that the instrument is not sensitive to area trends. Results remain generally consistent with those in previous tables.

[Include Tables 7 here]

6. Conclusions

[17] Information on plant closure is, in fact, recovered for 2005 and 2007 only. As such, 2SLS estimates are performed on a reduced sample that excludes the last wave of CIS (2006-2008).

The evidence presented in this paper shows that risk awareness may push some firms to increase their strategic assets and long-term resilience by investing in innovation as a way to prevent or reduce economic damages stemming from risky events. Yet, whereas single domestic firms seem generally to reduce their innovative efforts in presence of uncertainty, the positive relationship between perceived risk and innovation is mainly driven by the behaviour of firms belonging to MNE groups, both foreign and nationally owned. However, this gap between multinational and domestic firms tends to disappear in technologically dynamic environments, which offer high opportunities and the possibility to implement explorative and experimental innovation strategies.

These findings support in particular our hypotheses Hp 2 and Hp 4: the relation between risk perception and innovation engagement is moderated by firm-specific characteristics in terms of ownership advantages associated to 'multinationality' and MNE dynamic capabilities, but such effect is contingent upon the characteristics of the regional innovation system. In fact, in more connected and dynamic regions – because of both institutional and systemic features – risk perception operates mainly as a stimulus, rather than a deterrent, to innovation engagement to all firms, thus providing the conditions for faster adjustments to technological and demand shifts, strengthening in turn the regional resilience (e.g. Maskell and Malmberg, 1999; Boschma, 2004). Conversely, in technologically inert regions domestic firms confronting risk tend to lower their innovative efforts allegedly becoming increasingly vulnerable in the future. In such local environments risk may not be counterbalanced by much increase in opportunities, but MNEs may be able again to leverage their capabilities and experience gained across a variety of geographical locations: their global portfolio enable them to bear the risks and offset them (Malecki, 2010).

The interplay of O- and L-advantages and a unified micro-meso perspective on firms' innovative reactions to market risk constitute a crucial dimension to be considered in an evolutionary economic policy perspective, and certainly deserve further, possibly comparable, research (see

also Cooke and Morgan, 1993). The present analysis is, for example, unable to identify the nature of activities or functions undertaken in different regions by foreign-owned firms: however, MNE operations in more depressed and inert regions differ systematically from those undertaken in advanced and dynamic regionals systems. As Cantwell and Mudambi (2005) have shown, with specific reference to the UK, innovation strategies in competence-creating MNE subsidiaries are supply-driven, whilst those in competence-exploiting subsidiaries are demand-driven. Under these circumstances, market risk and demand uncertainty may end up counterbalancing any effect of policy intervention favouring foreign investment as a means to revitalise such technologically inert regions, allowing only the attraction of low value added operations and contributing to the vicious cycle of perceiving risk as a deterrent to innovation. Thus, the integration of demand and supply support to innovation and micro-meso policy approaches to favour active and passive internationalisation becomes all the more urgent, particularly in technologically sluggish and less connected regions. Reconciling cross-borders production and innovation networks with space-specific assets and institutional structures – i.e. the 'strategic coupling' process which ultimately drives regional economic development (e.g. Coe et al., 2004; Yeung, 2016) – is ultimately the only way to pursue future regional resilience.

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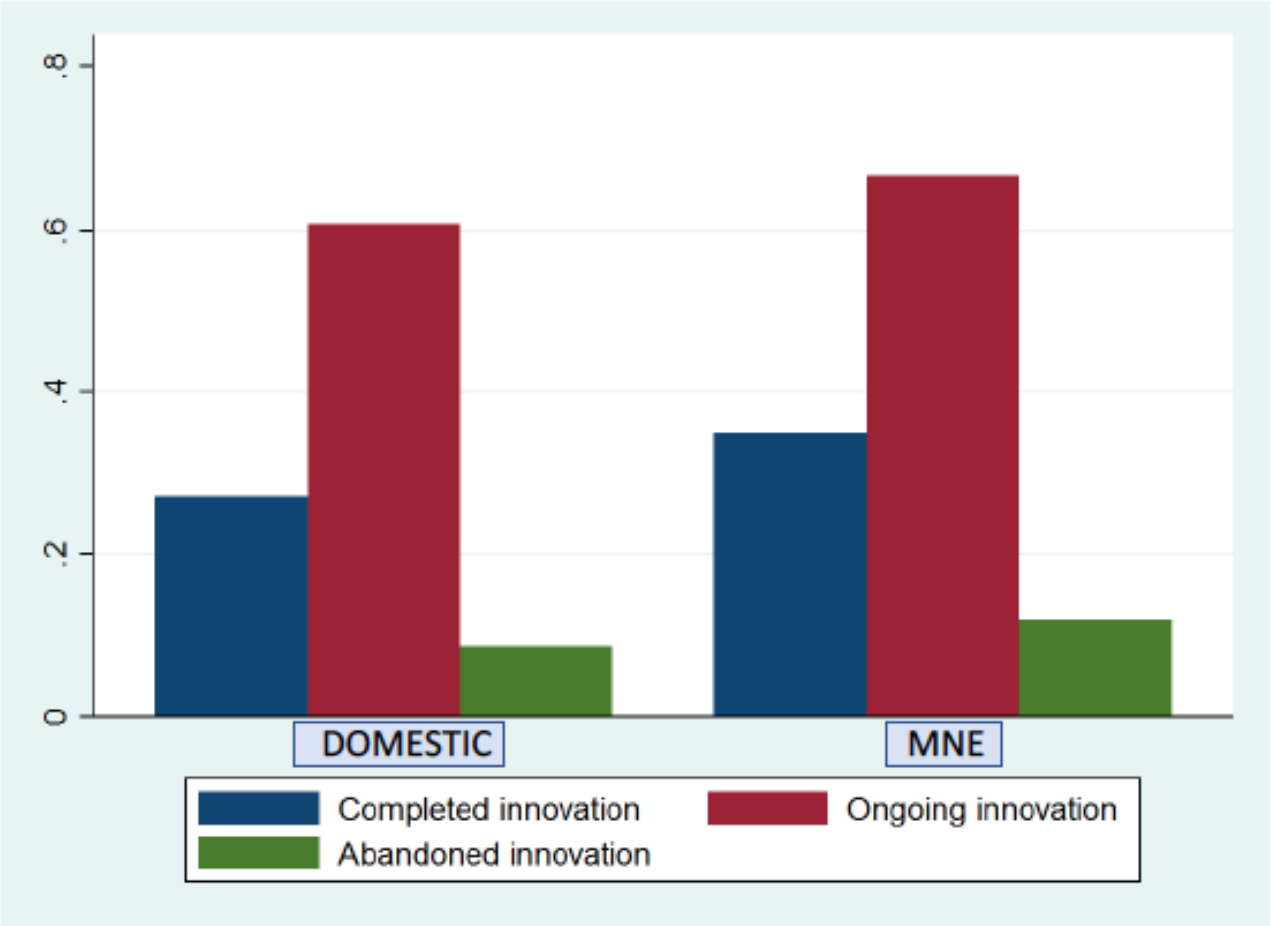
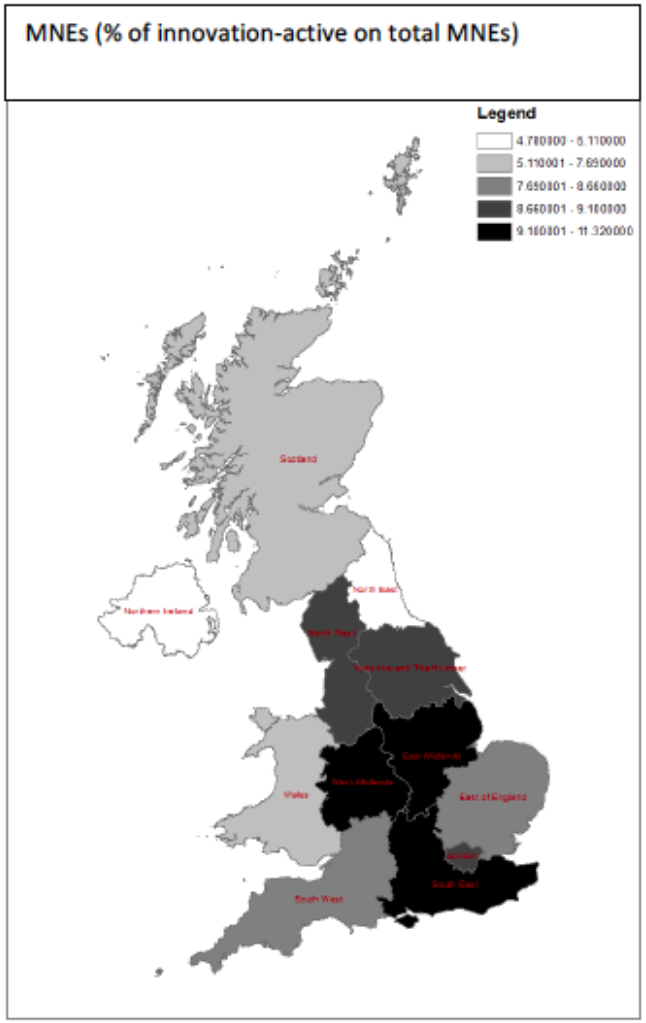
Figures

Figure 1 - Innovation behaviour in the UK: MNEs and single domestic firms



Source: authors' elaboration on ONS/CIS data

Figure 2 - Innovation-active firms across UK regions – MNEs vs single domestic firms



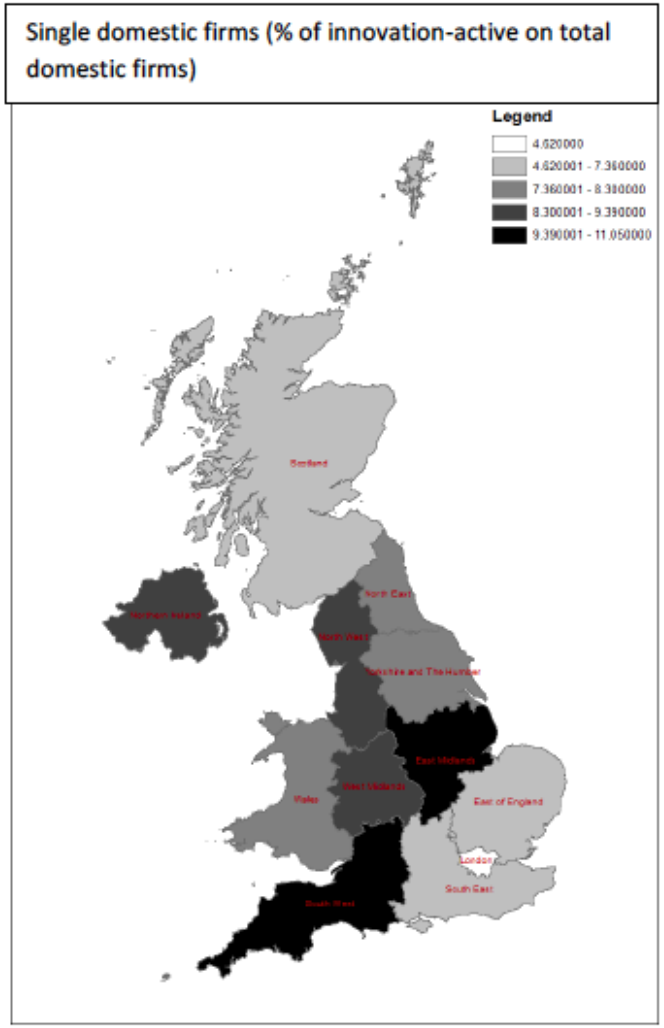
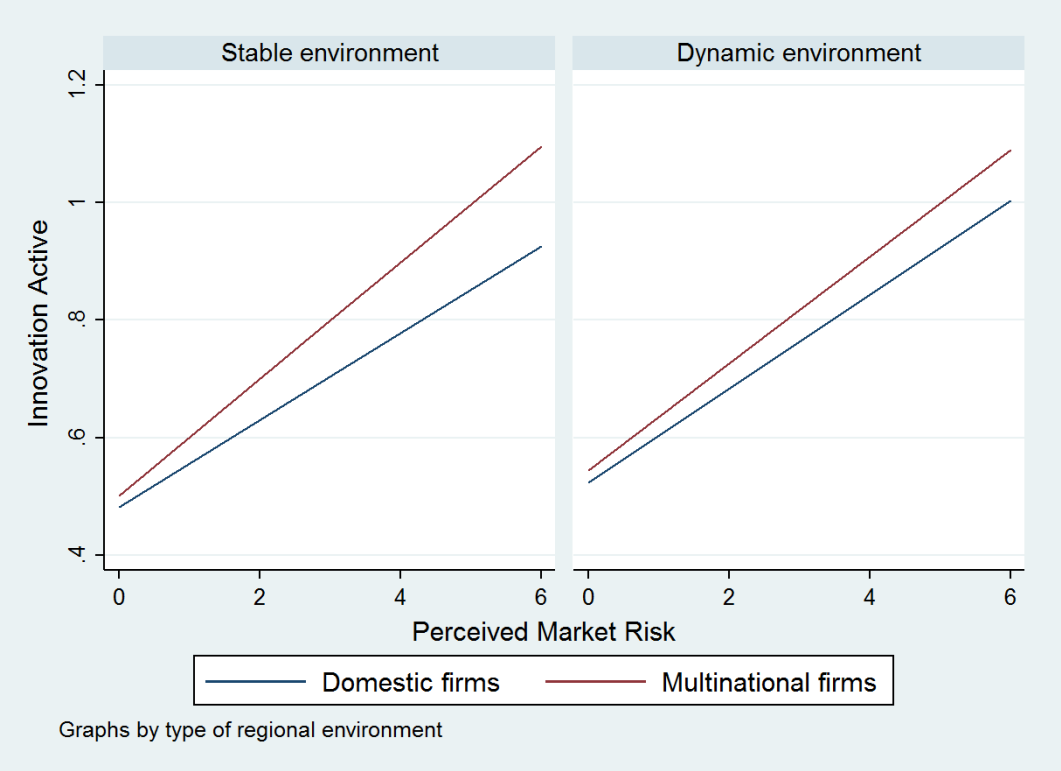


Figure 3 – The relationship between firm innovation engagement and perceived market risk by regional environment and firm ownership status



Tables

Table 1 - Firms' innovation status and perceived market risk

	MNEs			Single domestic firms			Total		
	No.	**Share**	**Perceived Risk (%)**	**No.**	**Share**	**Perceived Risk (%)**	**No.**	**Share**	**Perceived Risk (%)**
Innovation-active	5,361	69.24	51.59	2,770	62.85	48.48	8,131	66.92	50.53
Innovation-inactive	2,382	30.76	16.79	1,637	37.15	21.87	4,019	33.08	18.86

Source: authors' elaboration on ONS/CIS data

Table 2 - Innovation-active firms, perceived risk and degree of regional technological dynamism across regions

Government Office Region	Innovation-active (%)	Perceived risk (%)	Regional dynamism
North East	5.98	51.03	0.029
North West	9.10	49.86	0.027
Yorkshire and The Humber	8.82	52.02	0.025
East Midlands	10.39	52.19	0.019
West Midlands	9.72	49.87	0.024
East of England	8.22	51.35	0.027
London	7.51	50.90	0.037
South East	9.94	47.65	0.033
South West	9.19	50.07	0.027
Wales	7.16	47.94	0.027
Scotland	7.51	50.90	0.021
Northern Ireland	6.47	53.42	0.027

Source: authors' elaboration on ONS/CIS data

Table 3: Innovation and perceived risk: ownership and location advantages

	(1)	(2)	(3)	(4)
Dep.Var.: Innovation-active	FE	FE	FE	FE
Perceived risk	0.0589***	0.0673***	0.0674***	0.126***
	(0.00306)	(0.00385)	(0.00385)	(0.0373)
Domestic x Perceived risk		-0.0213***	-0.0215***	-0.0208***
		(0.00618)	(0.00618)	(0.00618)
Regional dynamism			-0.0265	-0.0528*
			(0.0223)	(0.0303)
Regional dynamism x Perceived risk				0.0161
				(0.0102)
Employment with degree	0.0619***	0.0614***	0.0613***	0.0614***
	(0.00448)	(0.00448)	(0.00448)	(0.00447)
Constant	0.466***	0.464***	0.368***	0.272**
	(0.00918)	(0.00920)	(0.0814)	(0.111)
Observations	12,150	12,150	12,150	12,150
R-squared	0.104	0.106	0.106	0.106
Time FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4: Innovation, perceived risk and ownership by regional contexts

	(1)	(2)
	Stable regional environments	Dynamic regional environments
Dep.Var.: Innovation-active	FE	FE
Perceived risk	0.0627***	0.0672***
	(0.00691)	(0.00702)
Domestic x Perceived risk	-0.0228**	0.00299
	(0.0108)	(0.0115)
Employment with degree	0.0550***	0.0579***
	(0.00827)	(0.00772)
Constant	0.481***	0.457***
	(0.0165)	(0.0156)
Observations	6,246	5,904
R-squared	0.094	0.116
Time FE	YES	YES
Firm FE	YES	YES

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 5: Alternative obstacles to innovation

	(1)	(2)	(3)	(4)	(5)
Dep.Var.: Innovation-active	FE	FE	FE	FE	FE
Perceived risk	0.122***	0.124***	0.126***	0.112***	0.112***
	(0.0374)	(0.0373)	(0.0374)	(0.0372)	(0.0373)
Domestic x Perceived risk	-0.0208***	-0.0208***	-0.0208***	-0.0210***	-0.0210***
	(0.00619)	(0.00618)	(0.00618)	(0.00616)	(0.00617)
Regional dynamism	-0.0551*	-0.0527*	-0.0529*	-0.0542*	-0.0560*
	(0.0303)	(0.0303)	(0.0303)	(0.0302)	(0.0302)
Regional dynamism x	0.0166	0.0162	0.0161	0.0164	0.0168*
Perceived risk	(0.0102)	(0.0102)	(0.0102)	(0.0101)	(0.0102)
Employment with degree	0.0611***	0.0613***	0.0613***	0.0607***	0.0606***
	(0.00447)	(0.00447)	(0.00447)	(0.00446)	(0.00447)
Employment barriers	0.0540***				0.0459***
	(0.0116)				(0.0123)
Information barriers		0.0196*			-0.00718
		(0.0119)			(0.0127)
Competition barriers			0.00371		-0.00704
			(0.0116)		(0.0119)
Financial barriers				0.0881***	0.0820***
				(0.0125)	(0.0125)
Constant	0.259**	0.271**	0.271**	0.258**	0.249**
	(0.111)	(0.111)	(0.111)	(0.111)	(0.111)
Observations	12,150	12,150	12,150	12,150	12,150
R-squared	0.108	0.107	0.106	0.111	0.113
Time FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 6: Results across industries and controls for area and industry trends

	(1)	(2)	(3)	(4)	(5)
	High-Tech	Non High-Tech	Area trends	Industry trends	Area and Industry trends
Dep.Var. Innovation-active	FE	FE	FE	FE	FE
Perceived risk	0.171**	0.0948**	0.123***	0.127***	0.124***
	(0.0761)	(0.0435)	(0.0373)	(0.0374)	(0.0373)
Domestic x Perceived risk	-0.0186	-0.0212***	-0.0210***	-0.0205***	-0.0206***
	(0.0132)	(0.00703)	(0.00617)	(0.00618)	(0.00618)
Regional dynamism	-0.0662	-0.0394	-0.0763**	-0.0539*	-0.0768**
	(0.0628)	(0.0349)	(0.0315)	(0.0303)	(0.0315)
Regional dynamism x	0.0264	0.00840	0.0155	0.0163	0.0157
Perceived risk	(0.0211)	(0.0118)	(0.0102)	(0.0102)	(0.0102)
Employment with degree	0.0786***	0.0542***	0.0613***	0.0611***	0.0610***
	(0.00783)	(0.00544)	(0.00448)	(0.00448)	(0.00448)
Constant	0.143	0.341***	0.207*	0.267**	0.206*
	(0.227)	(0.128)	(0.115)	(0.111)	(0.115)
Observations	2,698	9,452	12,150	12,150	12,150
R-squared	0.164	0.090	0.109	0.108	0.110
Time FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 7: Instrumental variable estimation

	(1)	(2)	(3)
Dep.Var.: Innovation-active	FE	2SLS	2SLS
Perceived risk	0.0581***	0.252**	0.260**
	(0.00436)	(0.101)	(0.105)
Regional dynamism			-0.0501
			(0.0343)
Employment with degree	0.0508***	0.0217	0.0205
	(0.00614)	(0.0168)	(0.0174)
Observations	8,100	8,100	8,100
R-squared	0.088	-0.402	-0.442
Time FE	YES	YES	YES
Firm FE	YES	YES	YES
Dep.Var.: Perceived risk		First Stage	First Stage
Plant closure		-1.6758***	-1.6343***
		(0.5239)	(0.5244)
Regional dynamism			0.1565*
			(0.0903)
Employment with degree		0.1521***	0.1521***
		(0.2193)	(0.0219)
Observations		8100	8100
R-squared		0.0685	0.0592
Time FE		YES	YES
Firm FE		YES	YES
Kleibergen-Paap rk Wald F statistic		10.23	9.71

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Appendix

Table A.1 - Key variables – Panel vs Single waves

Wave	Panel			Single waves		
	Innovation-active		Perceived risk	Innovation-active		Perceived risk
	Number	Share	Share	Number	Share	Share
2004	2,668	65.88	55.21	10,246	62.3	57.24
2006	2,957	73.01	39.47	10,325	69.43	41.07
2008	2,506	61.88	58.62	8,673	60.73	58.68

Source: authors' elaboration on ONS/CIS data

Table A.2 - Variable List

Variable name	Description
Innovation-active	Dummy variable taking values 1 if the firm is innovation-active and 0 otherwise, by firm-wave
Perceived risk	Variable based on a Likert scale ranging from 1 to 6 by firm-wave
Domestic	Dummy variable taking value 1 if the firm is a single domestic enterprise and 0 otherwise, by firm-wave
Regional Dynamism	Degree of technological dynamism, by region-wave. Variable constructed by attributing employment fluctuations at the national level in HT Manufacturing and KIS by wave to regions based on their industry specialization in 1998.
Employment with degree	(Log) number of employees with a university degree, by firm-wave
Human capital barriers	Dummy variable taking value 1 if the firm ranks as high the "lack of qualified personnel" as obstacle to innovation and 0 otherwise, by firm-wave
Information barriers	Dummy variable taking value 1 if the firm ranks as high the "lack of information on technology or market" as obstacle to innovation and 0 otherwise, by firm-wave
Competition barriers	Dummy variable taking value 1 if the firm ranks as high the "market dominated by established businesses" as obstacle to innovation and 0 otherwise, by firm-wave
Financial barriers	Dummy variable taking value 1 if the firm ranks as high the "difficulties in financing innovation investments deriving from their excessive cost or from the lack of appropriate financial resources" as obstacle to innovation and 0 otherwise, by firm-wave
Exploration	Dummy taking value 1 if the firm performs any exploration strategy and 0 otherwise, by firm-wave

Source: ONS/UKIS data and ONS/BSD Data

Table A.3 - Robustness Checks

Dep.Var.: Innovation-active	(1) PROBIT	(2) FE	(3) Stable regional environments	(4) Dynamic regional environments
Perceived risk	1.021***	0.105***	0.0625***	0.0697***
	(0.304)	(0.0377)	(0.00694)	(0.00965)
Domestic x Perceived risk	-0.173***		-0.0227**	-0.00525
	(0.0465)		(0.0108)	(0.0148)
UK MNE x Perceived risk		0.0201***		
		(0.00711)		
Foreign MNE x Perceived risk		0.0215***		
		(0.00742)		
Regional dynamism	-0.442***	-0.0527*		
	(0.156)	(0.0303)		
Regional dynamism x Perceived risk	0.153*	0.0160		
	(0.0812)	(0.0102)		
Employment with degree	0.355***	0.0614***	0.0555***	0.0474***
	(0.0287)	(0.00447)	(0.00830)	(0.0111)
Constant		0.272**	0.486***	0.452***
		(0.111)	(0.0164)	(0.0210)
Observations	6,042	12,150	5,924	4,071
R-squared		0.106	0.094	0.103
Time FE	YES	YES	3,345	2,770
Firm FE	YES	YES	YES	YES

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. In column 1 the number of observations decreases due to lack of convergence when running the xtprobit routine. Columns 3 and 4 exclude observations for London and the South East

Table A.4 - Exploration strategies by regional technological dynamism

	(1)	(2)
	Stable regional environments	Dynamic regional environments
Dep.Var.: Exploration	FE	FE
Perceived risk	0.0822***	0.0799***
	(0.00709)	(0.00713)
Domestic x Perceived risk	-0.0415***	-0.0210*
	(0.0102)	(0.0119)
Employment with degree	0.0490***	0.0347***
	(0.00788)	(0.00721)
Constant	0.254***	0.285***
	(0.0159)	(0.0157)
Observations	6,246	5,904
R-squared	0.121	0.107
Time FE	YES	YES
Firm FE	YES	YES

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1