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Innovation and Peripherality: A Comparative Study in Six EU Member Countries

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Innovation and Peripherality: An Empirical Comparative Study of SMEs in Six EU Member Countries

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Abstract

This paper examines innovation activity rates of SMEs located in central areas and equally developed peripheral areas among six EU member states. The probability to innovate is well predicted by observable firm characteristics, particularly the firms' size in terms of employment and the firms' age since establishment. More central areas present, consistently, higher activity rates than their remote and peripheral counterparts. The difference in innovation activity rates between peripheral and central areas is decomposed to observable and non-observable factors. The whole innovation gap is attributed to non-observable factors constituting a mix of 'behaviour and environment'.

1. Introduction

Innovation is an acknowledgeable factor of regional economic development and growth (Howells, 2005). The incentive to innovate determines the rate of technological progress which in turn determines the economy's long-run growth rate (Romer, 1990; Grossman and Helpman, 1991; Howitt and Aghion, 1998; Aghion, 2005). However, innovation is unequally distributed in the European space with certain places commanding higher absolute and relative rates of innovation than others. There are numerous examples pointing out to the concentration of innovation (Fritsch, 2000; Paci and Usai, 2000; Greenhalg et al., 2001). The innovative advantage of central places is well documented (Audretsch, 2002) and thus it is not surprising that higher levels of innovative activity are related to higher levels of regional accessibility (Copus and Skuras, 2006). Of course, there is no benchmark by which to compare the innovative activity in less accessible regions and conclude whether innovative activity is higher or lower than what would be expected by their location. Indirectly, however, one may link the presence of innovative activity to the observed absolute and relative growth and assert that higher levels of regional growth presuppose high innovation rates.

Peripherality is "the condition experienced by individuals, firms and regions at the edge of a communication system, where they are away from the core or controlling center of the economy" Goodall (1987, p.350). As such, urban principles are not always appropriate to describe the economic development of peripheral areas, frequently described as being “backward”, “lagging” or “stagnant” (Gatrell, 1999). Being peripheral means, as regards to enterprises, that they lack the convenience of having physical communication and highly skilled staff (Romijn & Albaladejo, 2001), and have to pay the extra cost to manufacture or to service, as their scale of production and their access to professional labour and advice is limited since their larger suppliers and customers are distant (Anderson, 2000; Fynes and Ennis, 1997). When entrepreneurship in peripheral regions of Europe is examined, Anderson (2000) and Perry (1987) conclude that there is an over proportional share of labour- intensive SME’s in regions away from the core and that they face many problems to overcome distance (Keeble, 1990). Smallbone et al (1993) report that markets served by rural SME’s are usually distant and non-local. Mason (1991) tries to explain the high rates of new manufacturing firms in the Highlands and Islands of Scotland and comments that those related to tourism, are usually craft based and not oriented to growth. He also notes that there is “lack of new firms in finance, property and professional services sectors…explaining that core regions have the highest concentration of managerial and skilled staff”. Consequently, what actually is important regarding proximity is not the reduction of physical distance as such, but the possibility to easily exchange information through frequent personal contacts and mobility, as well as similar cultural attitudes (Camagni, 1991) and access to skilled labour and specialized services.

Regionalization of innovation may be attributed to firm and region specific attributes, a fact that calls for specific measures within a regionalized innovation policy. Keeble et al (1988) argue that innovation is developed firstly in the core and later it may spread in the periphery. This happens due to the possibility of the firms located in the core having direct access to information networks and highly skilled staff. Moreover, the success of innovations is more possible in core areas, where people are more open to new ideas and keener to buy new products. Empirical studies show that peripheral zones are characterized by low innovation potential (concerning mainly product and to a lesser extent process innovation) and technological dynamism (Burca, 1997; North and Smallbone, 1996; Keeble et al, 1992) and they also demonstrate that small high-tech firms are more probable to be located in accessible, rather than remote rural areas. Frenkel (2000) shows that in Israel, peripheral regions attract innovative firms of the traditional industry, while innovative high-tech firms are located in metropolitan and intermediate regions. A basic reason for this is the fact that the periphery does not seem to provide a supportive innovative milieu, as it lacks highly skilled labour. On the contrary, Keeble and Tyler (1995), show that in England accessible rural firms are more innovative, dynamic and develop more in-house technological expertise than their urban or remote rural counterparts.

Roper et al (2000) conclude that “locational factors are an important influence on plants’ innovation propensity reflecting regions’ industrial composition, level of R&D activity, external ownership, preponderance of small firms and general level of propensity”. Rope et al (2000) find that the share of regional employment in small firms is unequally distributed in space, a finding supporting the notion that “small firms are the catalyst for technological change”. One of the locational factors relating to innovation is the cultural characteristics of the residents of a certain location. According to Audretsch (1998) and to Jones & Davis (2000), cultural characteristics have a strong relation to “national rates of invention and innovation, R&D productivity, the initiation and implementation of new product development, the ability to source or adopt innovations and organizational entrepreneurship” (Hofstede, 1980; Shane, 1992;

Shane, 1993; Kedia et al, 1992; Nakata et al, 1996; Herbig et al, 1992; Herbig, 1994; Morris et al, 1994). According to Rodriguez-Pose (2001) and Bilbao-Osorio and Rodriguez-Pose (2004), there is a variety of social, political and economic factors affecting the capacity of an area to transform its innovative investment into economic activity and growth. These include the economic structure of the area (Rodriguez-Pose, 1998; Roper, Hewitt- Dundas and Love, 2004), the firm's age and size, the industrial potential of the region (Acs & Audretsch, 1990; Audretsch, 1995), any existing cooperation among firms (Cooke and Morgan, 1988), the characteristics of local labour force, the local labour market and of local entrepreneurs, as well as demographic characteristics of the area. Rodriguez-Pose (1999) argues that different "social filters" are also responsible for the capacity for the transformation of R&D and innovation into economic growth. Taking into account this capacity, Rodriguez-Pose makes a distinction between "innovation- prone" and "innovation- averse" societies, the first ones being more capable than the second ones.

In the present paper we analyse a dataset of firms located in twelve regions of six EU member states. For each member state, firms are sampled from a peripheral area which, however, presents high levels of development, and form a central region that presents similar development levels. In Section 2 of this work, the rationale for data collection, the case study areas and sampling procedures are presented. The aim of this work is twofold. First we attempt to identify the observable firm characteristics that explain regional innovation rates and compare innovation rates when comparing peripheral and more central regions. Second, we attempt to identify the observable firm characteristics that can offer an explanation regarding the difference in innovation rates when comparing peripheral and more central areas. In other words, we attempt to examine whether firm observable characteristics can offer an explanation regarding innovation rates as well as the difference (gap) in innovation as far as certain regions are concerned. The econometric framework employed in this work is presented in Section 3. Our major findings are presented in Section 4, pointing out that while firm observable characteristics can explain region specific innovation rates, they cannot explain differences in innovation activity rates across regions. In other words, firm observable characteristics can explain region specific innovation rates but not cross-regional differences in innovation rates and thus we provide empirical evidence that the observed regional gap in innovation rates is due to unobserved factors. In Section 5 of this work it is argued that these findings may have important implication for the design of regionalized innovation policy. In the same section we explore the implications of our findings for future research.

2. Rationale for data collection, case study areas, and sampling

In order to explore the relative importance of observable firm characteristics versus "unobserved" characteristics of the regional business environment, survey data collected in twelve case study regions in six EU member states was used. This data was collected during 2003 for the EU Fifth Framework research project entitled "Aspatial Peripherality, Innovation and the Rural Economy" (AsPIRE)[1]. Within each of the six participating member states, one region (known as Region A) was selected as a relatively peripheral region which was perceived to be performing relatively well economically (given its locational disadvantages), and one (Region B) was selected as an example of a relatively accessible region with relatively similar to region A performance. The hypothesis was that the success of regions of the first type could be attributed to relatively high rates of innovative activity, associated with soft "aspatial" local characteristics (in the realm of human and social capital, governance and business network characteristics). Conversely, the economic trends in the B regions could be attributed to low rates of innovation due to shortcomings in these environmental aspects. The overall conclusions are reported in detail elsewhere[2], and it is sufficient to state here that whilst evidence (mainly qualitative) was found to support the hypothesis mentioned above, it also became clear that the "syndrome" of disadvantage associated with peripherality remains an important constraint to economic development, although the details are evolving in response to changes in technology and logistics.

The twelve case study regions are listed in Table 1 and mapped in Figure 1. Several of the regions equate to Eurostat NUTS 3 regions, allowing the use of harmonised secondary data for contextual purposes (Table 2). In some instances (such as East Ayrshire, and the Irish, Spanish and Finnish regions) the NUTS 3 region was considered too large, and a smaller sub-region was adopted as the basis for the sampled firms.

In Scotland, Shetland is an extremely peripheral region, exhibiting low population density, out-migration, and a relatively high dependence upon primary and secondary industries (Table 2). However, Shetland has a relatively high GDP per capita, and this serves to support its perceived "Region A" character (i.e., performing better than its geographical position might lead one to expect). East Ayrshire, by contrast, is a relatively accessible region, whose economy was formerly dominated by heavy industries. It is more densely populated than Shetland, but is has also experienced net out-migration. It has a much more important tertiary sector than Shetland, but at the same time it has the lowest GDP per capita of any region in Scotland. It was therefore selected as Scotland's "Region B".

In Ireland the two case study regions County Clare (A) and County Wexford (B) have both seen population growth in recent years (as has much of Ireland), although it has been at a slower rate in the less accessible County Clare. GDP per capita figures are not available for the Irish Counties, though the surrounding NUTS 3 regions (Mid-West and South East) suggest that Clare is slightly more prosperous. The study regions were primarily selected on the basis of the perception that Clare is rather more dynamic (though this is at least partly driven by US inward investment) than Wexford, which is restructuring away from the primary sector rather slowly, and in some senses has become a long distance commuting zone for Dublin.

Both the Spanish case study regions are located within the NUTS 2 region Comunidad Valencia. The A region, L'Alcoià, is a relatively inaccessible mountainous area, in which the primary sector is relatively unimportant, but the secondary sector is relatively large and diverse. The B region is the more accessible El Camp de Morvedre. In this latter region, large scale industries (based upon iron and steel) closed down in the 1980's.Unemployment is still relatively high and average incomes are low. Contrary to the perception of these two areas, - which resulted in their selection as "A" and "B" regions - L'Alcoià has experience declining population in recent years, whilst El Camp de Morvedre has shown modest growth.

In Greece, Evrytania was chosen as Region A. This also is a totally mountainous region, with poor road communications to Athens. The economy of the area is dominated by the service sector, especially tourism, while agriculture (by Greek standards) is of less importance. The area has shown a relatively rapid increase in GDP over the past decade. GDP per capita is now approximately 30% higher than in the B region, Kalavryta. The latter, though fairly mountainous, is accessible by the major cities of Athens and Patras. This region has recently lost manufacturing employment, and still is rather dependent upon agriculture and tourism.

Rottal-Inn, on the Austrian border, was selected as “Region A” in Germany. Although predominantly rural, with an important agricultural base, it is characterized by a strong SME manufacturing sector. It has exhibited population growth in recent years, and has a relatively high GDP per capita. Bitburg-Prum, on the borders with Luxemburg and Belgium, was selected as the “B” region. This region has never developed much manufacturing industry, and until tourism began to expand in recent decades it was largely dependent upon farming and forestry. It has a GDP per capita of only 72% of the German average.

Finally, in Finland, the case study regions were Keski-Suomi (Central Finland), and Satakunta. The former is less accessible, but has a relatively dynamic secondary sector, originally based around forestry and paper making, but more recently expanding into high technology industries, seemingly benefiting from the presence of a University at Jyväskyä. Satakunta (B), though accessible by Helsinki, is characterised by a mix of declining heavy industries and smaller scale more modern activities. The region is experiencing population decline, and despite its relatively favourable location, its GDP per capita is similar to that of Keski Suomi.

It should perhaps be stressed that the selection of case study areas was not primarily based upon secondary indicators such as those presented in Table 2, but upon the perceptions of both the research teams and other national experts. In each case study area a survey of approximately 50 businesses took place. A two-stage, sampling procedure was devised (quota, then representative stratified). The sample of 50 businesses in each area was drawn from the manufacturing and service sectors (as defined by the NACE Divisions) while agriculture was excluded. Each sample was proportionately stratified so as to yield a representation of the distribution of micro, small and medium firms in each case study area. Samples were drawn from sampling frames provided, in each country, by the respective authorities such as national and regional statistical services, chambers of industry and commerce and others. The sectoral distribution of surveyed businesses is shown in Table 3.

The questionnaire was pre-tested in each country and was designed to be administered face to face with the manager of the firm on a pre-arranged meeting. A very small proportion of firms, less than 10%, denied participating in the survey. These firms were replaced by firms from the same sector and of an equal size as those that denied participation. The majority of the questions were closed, simply requiring from the interviewee a number, ticking off a series of options, or a response to an attitudinal scale. In accordance with the concepts described in the introduction above, innovation was judged in terms of the entrepreneur’s self assessment (whether they felt they had introduced a new product, process or marketing strategy into the region or the individual firm).

3. Modeling regional innovation rates

We assume that an individual firm derives utility from innovative activity, U. The firm makes a marginal benefit-cost calculation based on the utility achieved by introducing the innovation as well as by not introducing it. Since marginal benefit is not observable, we model the difference between the sum of the stream of expected benefits and costs as an unobserved variable y^* such that:

$$y^* = \boldsymbol{\beta}'\mathbf{x} + \varepsilon \tag{1}$$

where $\mathbf{x}$ is a vector of observed firm characteristics, $\boldsymbol{\beta}$ a vector of coefficients to be estimated and ε an error term. In the above formulation, $\boldsymbol{\beta}'\mathbf{x}$ is called the index function. Since we do not observe the net expected benefits from the introduction of the innovation but only whether this was actually introduced or not, our observation is:

$$\begin{aligned} y &= 1 \text{ if } y^* > 0 \\ y &= 0 \text{ if } y^* \le 0 \end{aligned} \tag{2}$$

If we assume that the error term has a standard normal distribution, the probability that a firm reports innovative activity, i.e. that $y = 1$, becomes

$$\Pr(y^* > 0) = \Pr(\boldsymbol{\beta}'\mathbf{x} + \varepsilon > 0) = \Pr(\varepsilon > -\boldsymbol{\beta}'\mathbf{x}) = \Pr(\varepsilon < \boldsymbol{\beta}'\mathbf{x}) = \Phi(\boldsymbol{\beta}'\mathbf{x}) \tag{3}$$

that takes account of the fact that the normal distribution is symmetric and the function $\Phi(.)$ denotes the standard normal distribution. The effects of the independent variables included in the vector $\mathbf{x}$ on the change in the probability that $y = 1$, are

$$\frac{\partial E[y|\mathbf{x}]}{\partial \mathbf{x}} = \phi(\boldsymbol{\beta}'\mathbf{x})\boldsymbol{\beta} \tag{4}$$

where the function $\phi(.)$ denotes the standard normal density.

Once the above probit model is estimated for a sample of firms, the mean sample innovative activity can be computed. For example, the mean sample innovative activity rate for firms located in regions A is:

$$\hat{y}^A = \overline{P}^A(\hat{\boldsymbol{\beta}}', \mathbf{x}) = \frac{1}{N^A}\sum_{i=1}^{N^A}\Phi(\hat{\boldsymbol{\beta}}'\mathbf{x}) \tag{5}$$

where N^A is the sample size of firms in regions A. Gomulka and Stern (1990) in Appendix 2 of their work present Peter Robinson's theorems implying consistency and asymptotic normality of $\hat{y}$ and provide an expression for its limiting variance that allows the calculation of standard errors for these estimated sample proportions. The difference between average innovation proportions in two regions A and B ($\hat{y}^B - \hat{y}^A$) can be decomposed, following the decomposition scheme suggested by Gomulka and Stern (1990) for probit models, as follows:

$$\hat{y}^B - \hat{y}^A = \left\{\overline{P}(\boldsymbol{\beta}^{\mathbf{B}}, \mathbf{x}^{\mathbf{B}}) - \overline{P}(\boldsymbol{\beta}^{\mathbf{A}}, \mathbf{x}^{\mathbf{B}})\right\} + \left\{\overline{P}(\boldsymbol{\beta}^{\mathbf{A}}, \mathbf{x}^{\mathbf{B}}) - \overline{P}(\boldsymbol{\beta}^{\mathbf{A}}, \mathbf{x}^{\mathbf{A}})\right\} \tag{6}$$

where $\overline{P}(\boldsymbol{\beta}^{\mathbf{A}}, \mathbf{x}^{\mathbf{B}})$ is the average predicted innovation activity rate across firms in regions B, with characteristics captured by the vector $\mathbf{x}^{\mathbf{B}}$ but using the coefficients estimated by the sample of firms in regions A ($\boldsymbol{\beta}^{\mathbf{A}}$). The first term in braces describes the change in average innovation rates arising from the changing coefficients whereas the second term describes the changes arising from the changing population. In other words, decomposition attempts to assess how much of the innovation activity difference between two regions is due to observable characteristics of the firm populations (the second term in braces which represents the part of the innovation activity difference due to group differences in distributions of $\mathbf{x}$, i.e., observed differences in firm characteristics in the two regions) or due to behavioural and other unobserved factors reflected in the coefficients of the model (the first term in braces which captures the part of the innovation activity difference due to group differences in unmeasurable or unobserved endowments).

4. Results

Innovation Activity

The search for the best econometric model of the occurrence of innovation in a firm was guided by two criteria. First, we searched for a plausible and theoretically informed model from an economic and geographic point of view, and second for the model with the best econometric properties among alternative models. In that respect, we included in our models reliable factual variables, i.e., variables recording objectively measured and cross-validated facts excluding variables for which we were not able to judge their validity. For example, a firm's size measured in labour units and its age measured in years since first establishment are reliable variables as they were easily cross-validated with figures kept in official records. Other variables, especially those referring to personal data could not be easily cross-validated. Furthermore, variables recording the respondent's perceptions or attitudes were excluded from the present analyses. For example, a variable recording the respondent's perception of firm location or of the expected evolution of the demand for the firm's goods or services in the next five years were excluded due to the fact that they record perceptual and not factual data. Variables that were not statistically significant were excluded from the analysis with the exception of a dummy variable capturing a firm's operation in the manufacturing or services sectors of economic activity. Furthermore, various variables entered the analysis into various functional forms. For example, we tried to capture non-monotonic effects of a firm's size on innovative activity by including the squared and log size without improving the model's overall fit or statistical significance.

The final model explaining innovative activity rates is based on six uncorrelated explanatory variables, namely, the firm's size, age since establishment, sector of economic activity, its past location, the location of its financial sources and its relations with clients and customers. The discussion of our results below, details how these variables have been used in the relevant scientific literature. Table 4 presents descriptive statistics for the variables used in the econometric models of innovative activity rates. Innovative activity was carried out by almost 70% of participating firms. This overall rate of innovative activity is very close to the rate reported by other studies in Europe (see for example Reichstein, 2004 for Denmark, Monhen and Dagenais, 2002 for a comparative study of Denmark and Ireland with data drawn from the Community Innovation Survey 1 and Roper, 1997 for a comparison of German, U.K and Irish firms and Isaksen, 2003 for a comparative study of seven EU member states and Norway). The economic performance indicators (table 2) would make us believe that innovative activity rates in regions A should have been equal if not higher than the respective rates in regions B. Surprisingly, innovation activity rates are higher in regions B than in regions A and challenge the commonly shared view that higher growth levels in Europe are frequently associated with higher innovative activity.

For all models shown in table 5 we performed chi-square tests based on the maximized likelihood and jointly testing the null hypothesis that all the parameters associated with the explanatory variables in a model are equal to zero (0). A goodness-of-fit measure based on the likelihood-ratio test statistic, usually reported as McFadden's pseudo-R^2 measure, or rho-square (Maddala, 1983; 1995), is also computed for all models. McFadden (1979), has suggested that ρ^2 values of between 0.2 and 0.4 should be taken to represent a very good fit of the model. Specification test analysis involved tests for heteroskedasticity and groupwise heteroscedasticity for continuous and dummy independent variables respectively (Greene, 1997). In all models, the overall prediction rate, innovators and non-innovators ranges from 77.5% to 81.4%, which is a very satisfactory fit. However, one should note that correct predictions for innovators alone were above 80% in all models and, in certain cases this was easily attained by using only the size variable.

Model 1 of table 5 shows estimates of a probit model of innovative activity for all regions. A regional dummy (Region) indicating a firm's location in regions A or B is included among the independent variables. The coefficient of this regional dummy is statistically significant indicating that innovative activity is affected by a firm's location in regions A or B. In model 2 we estimate the same model without this regional dummy. Models 1 and 2 are nested and we can test the null hypothesis that the regional dummy's coefficient in model 1 is zero by carrying out a simple likelihood ratio test which shows that we cannot accept the null hypothesis[3]. In models 3 and 4 we estimate probit models of innovative activity for firms located in regions A (model 3) and regions B (model 4) separately. We tested whether it is
valid to pool the two subgroups together (as in model 2) or whether the sample should be partitioned into two subgroups (as in models 3 and 4). This homogeneity question can be addressed with a simple chi-square test which in our case shows that the two subgroups of firms located in regions A and B respectively should be estimated separately[4].

The estimated results for the pooled sample of firms in regions A and B (model 2) indicate that innovative activity is well predicted by factual (observable) and measurable firm characteristics including size, age, the firm's past location, its spatial source of investments and type of relations the firm maintains with its customers. The dummy capturing sector of economic activity is not significant indicating that there is not sector difference in the probability of innovation. In model 3 (firms located in regions A) only the size and age variables are statistically significant but are sufficient to produce a very good fit. In model 4 (firms located in regions B) only the dummy variable capturing the sector of economics activity (Sector) is not statistically significant. Our findings suggest that innovative activity increases with firm size and decreases with firm age since establishment for firms located in both regions (model 3 and 4), a finding that is in accordance with well documented findings in the relevant literature and does not deserve further discussion (Frenkel, 2000; Smallbone et al, 1999; Acs and Audretsch, 1988; 1990; 2005; Audretsch, 1995; Hansen, 1992; Rogers, 2004; Smith et al, 2002). The effect of firm size on the probability to innovate is linear and in accordance to findings by Diederen et al (2002), Baldwin et al. (2002) and Leiponen (2002).

For firms operating in regions B, those firms that have relocated to the area have higher probability of innovating than firms which started their operation in the area. Of course, the act of relocation itself may be linked to innovation because, frequently, firms relocate in order to take advantage of the new location's environmental resources, skills, regional image, etc. The same happens for firms maintaining formal relations with their clients. Demanding customers push best practices down into their supply chains (Porter, 1990; Harrison et al., 1996). Finally, firms raising investment capital outside the region in which they are located are more probable to innovate.

Innovation Activity Differences

Table 6 shows various predicted sample proportions of innovative activity. Down each column we have a fixed set of coefficients corresponding to the region associated with the column and a changing sample $(\mathbf{x})$. Along a row we see differences in predicted proportions for a given sample $(\mathbf{x})$, that result from using the estimated probit coefficients for the region associated with the row. The predicted average proportions of innovative activity for firms in regions A is 67% and for firms in regions B is 73% with a total difference in predicted proportions of 6%. If the coefficients of the probit model for firms in regions A are imposed on the characteristics of firms in regions B then the predicted proportion of innovative activity would be 66%, 1% less than the actual predicted proportion of 67%. This means that if in regions A the presence of firms with sample characteristics identical to those of firms in regions B was possible, the predicted proportion of innovative activity would not change much. In other words, the predicted innovative activity rate of firms in regions A is not due to their relatively smaller size or other firm specific characteristics that differ among firms in the two samples (see table 4). This is more evident if we notice that the predicted proportion of innovative firms in regions A rises from 67% to 75% when the vector of coefficients from the probit model for firms in regions B is imposed. The above discussion indicates clearly that the values of the observed firm characteristics can predict very well the average proportion of innovative activity but do not play a major role in predicting the observed differences of innovative activity proportions between firms located in regions A and B.

At this point it is important to note that a range of firm characteristics, other than those included in our models, have also been recorded and thus may be considered as observable firm characteristics. These observed characteristics do not present any statistically significant difference between firms located in regions A and B[5]. Among them we may refer to business specific characteristics such as business ownership, and method of business acquisition, and entrepreneur specific characteristics such as education, training and other human capital characteristics or characteristics of the businesses' relations to the wider social and institutional capital of the regions. As concerns with business ownership, almost 50% of the firms in each region are family owned and 33% are limited enterprises. From the human capital characteristics of the firms, the proportion of entrepreneurs in the different levels of formal schooling and the proportion of entrepreneurs that have undertaken training is not significantly different in the two types of areas. However, the proportion of entrepreneurs that had work, but not managerial experience is slightly higher among entrepreneurs in regions A. The same holds true for the proportion of entrepreneurs raised in an entrepreneurial family environment in the sense that one of the parents owned and run a firm in the area. The inclusion of these entrepreneur specific characteristics as dummy variables in our models predicting innovative activity did not yield any statistically significant results. Elements of the entrepreneur's social capital in the form of membership in different business, professional or non-business associations, and the entrepreneur's involvement with local administration are not statistically different between the two types of areas. Based on this discussion, it is safe to assume that the most important observable characteristics have been included in our model while other, important observable determinants of innovative activity do not present significant difference among firms and entrepreneurs in the two types of regions.

Thus, indeed, table 7 reveals that, taking into account the rationale behind choosing the specific areas, the significant 6% gap of innovative activity rates between regions A and B is due to differences in coefficients and not due to differences in observable firm characteristics. Despite the fact that firm characteristics offer a very good explanation for innovative activity rates, they cannot offer an explanation for the observed innovation gap among the two types of areas. In other words there exists a significant structural difference of innovation activity rates between regions A and B associated with unobserved factors, a combination of 'behaviour and environment' (Gomulka and Stern, 1990). The unobserved factors not measured or captured in our estimates, may account for institutional, cultural, attitudinal or even wider conventional economic differences among regions A and B. However, our intention is not so much to speculate on the possible factors causing this unobserved heterogeneity among regions A and B but to point out that unobserved heterogeneity is the cause of the regional innovation gap. Thus, observed firm characteristics are suitable determinants of innovation activity rate.
However, when innovation activity differences are considered, we should seek explanations outside our traditional innovation activity models and take account of the wide socio-cultural regional milieu.

Robustness of estimations

We have checked the robustness of our results in a number of ways. First, our results may be driven by the inclusion of regions from certain countries which exhibit extraordinary, low or high, innovation activity rates. We have run models 3 and 4 of table 5 and replicated the computations of tables 6 and 7 each time excluding one country. The results, shown in table 8 are similar in terms of sign patterns and statistical significance to the results for the whole sample. Moreover, irrespective of the country excluded from the sample, the difference in innovation activity rates is consistently attributed to unobserved regional heterogeneity or, in other words, the combination of 'behaviour and environment'.

Second, one could argue that innovative activity is more important in certain industries because technological progress and/or changes in the economic and institutional environment are more rapid. A vivid example is the food industry and specialized forms of tourism, especially in peripheral areas, with the renaissance of local and denominated food and rural tourism driven by customer demand and supported by institutional changes at EU level (for a review of these changes the interested reader can refer to Skuras and Dimara, 2004; Dimara and Skuras, 2005; Skuras et al., 2006). When the food industry firms are excluded from our sample, the results are similar in terms of sign patterns and statistical significance with the results for the whole sample. Again, the difference in innovation activity rates between regions A and B is attributed to unobserved regional heterogeneity.

Third, we divided manufacturing industries into ubiquitous and more specialized industries with the second sub-sample including industries presumably producing primarily for regional and/or national export. Skuras et al (2005a; 2005b) found that in a sample of firms located in peripheral regions of southern Europe, the growth of exporting firms was unfettered by the limits of local demand. Firms involved in local production and consumption systems presented limited growth. We run models 3 and 4 of table 5 and computed the probability decompositions of tables 6 and 7 using the two sub-samples separately. Firm size and age remain the strongest predictors of innovative activity rates while the difference in innovation activity rates between regions A and B is again attributed to unobserved regional heterogeneity.

5. Conclusions, Policy Implications and Future Research

More recent endogenous growth theory models view innovation and capital accumulation as complementary procedures in the growth process (Howitt and Aghion, 1998). In our study, the peripheral areas were chosen, among others, because of their nearly equal or higher GDP per capita levels in comparison to their centrally located counterparts. Despite their level of growth, peripheral areas do not attain the same innovative activity rates as the corresponding centrally located areas. Innovative activity rates are determined very precisely by firm observable characteristics. However, these observable firm characteristics fail to determine the gap between regional innovation rates. The observed difference of innovative activity rates between peripheral and more central areas is totally attributed to unobservable factors thus rendering regional heterogeneity. Our study provides empirical evidence that the processes generating regional innovation activity are different from the processes creating innovation activity gaps among regions.

It is argued that the success of innovation policy initiatives depends on a clear understanding of the firm specific factors constraining innovation activity (Hewitt-Dundas, 2006). Taking into account the empirical evidence provided by the present work, it sounds reasonable to suggest that the tools aiming to increase regional innovation activity rates cannot be the same as the tools aiming to bridge the gap between regional innovation activity rates, since, they target two different processes. Taking into account the great disparity in unobserved regional heterogeneity, there is empirical ground for proposing a regionalization of innovation policies as well as policies for the regional convergence of innovation activity. However, such proposals should not be made before further research is undertaken. Future research should address two issues. First, it must unravel the factors masked under terms such as 'regional heterogeneity' or 'behaviour and environment'. Second, it must identify the manner these factors operate in inhibiting or accelerating innovation activity convergence among regions. Thus, future research should provide a solid ground on which policy recommendations may be drawn.

Aghion (2005) states that 'new growth theories may be criticized by development economists and policy makers, precisely because of the universal nature of the policy recommendations that appear to follow from them: no matter how developed a country or sector currently is, it seems that one should prescribe the same medicines to maximize the growth prospects of that country or sector'. As a result, Aghion (2005) revisits Gerschenkron (1962) and argues that different institutions or policy design affects productivity growth differently depending upon a country's distance to the technological frontier which, in turn, affects the type of organizations observed in a particular country. These arguments on growth resemble very much the case of innovation or, in other words, the case of innovation as the dark side of growth.

Griliches (1979) was the first to formalize the Firm Knowledge Production Function in which he implicitly assumed that firms exist exogenously and then endogenously seek out and apply knowledge inputs to generate innovative output. If firms exist exogenously, then, the difference between innovative rates should be attributed to observable firm characteristics pertaining to the firms' ability to seek out and apply knowledge inputs in order to generate innovative output and not to unobservable factors. Audretsch (1995, pp. 179-180) challenged this view by arguing that it is the knowledge in the possession of economic agents that is exogenous, and in an effort to appropriate the returns from that knowledge, the spillover of knowledge from its producing entity involves endogenously creating a new firm. The Knowledge Spillover Theory of Entrepreneurship introduced by Audretsch (1995) and analytically presented in Audretsch (2005), Audretsch and Lehmann (2005) and Acs et al (2005), goes back to Arrow's (1962) recognition that knowledge is not the same thing as economically relevant knowledge, suggesting that spillovers may occur automatically (or falling like manna from heaven). The Knowledge Spillover Theory of Entrepreneurship recognizes that there are transmission mechanisms that determine the rate at which the stock of knowledge is converted into economically useful firm-specific knowledge and that these transmission mechanisms constitute a wedge that filters knowledge to economic knowledge.

Thus, whether regions experience high innovation activity rates depends just as much on the operation of the knowledge spillover filters. Re-phrasing Aghion's (2005) and Gerschenkron's (1962) view on development policies, we argue that innovation policies affect innovation activity differently depending upon an area's thickness of the knowledge filtering mechanisms, i.e., upon an area's efficiency in knowledge exploitation and its distance from a global knowledge exploitation frontier. Thus, one could argue that the unobservable factors generating the innovation activity gap among regions are not but the filtering mechanisms that confront areas from attaining higher innovation rates whatever the observable characteristics of their firms may be. Consequently, a regional innovation activity convergence policy should aim to dilute the thickness of the knowledge spillover filters in operation.

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Figure 1. The Case Study Regions

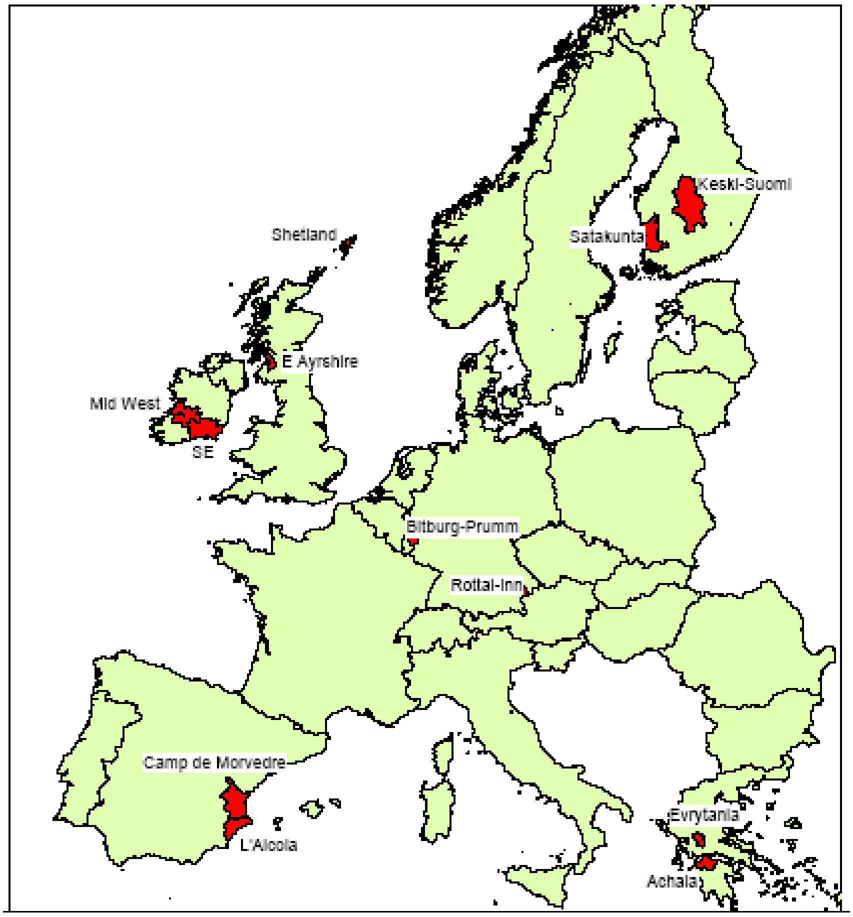

Table 1. The Case Study Areas

Member State	Region A	NUTS 3	Region B	NUTS 3
UK (Scotland)	Shetland	UKM46	East Ayrshire	UKM33
Ireland	Clare	IE023	Wexford	IE024
Spain	L'Alcoià	ES530	El Camp de Morvedre	ES530
Greece	Evrytania	GR243	Achaia (part)	GR232
Germany	Rottal-Inn	DE22A	Bitburg Prum	DEB23
Finland	Keski Suomi (part)	FI193	Satakunta (part)	ES530

Table 2: Some key socio-economic indicators for the Case Study Areas

	Region	Population 2003	Population Density 2003	Population Change 1994- 2003 (%)	% Primary Employment 2003	% Secondary Employment 3003	GDP per Capita 2002
UK (A)	Shetland	21.9	15.3	-4.4	10.3	23.1	18.8
UK (B)	East Ayrshire	*41.7*	*47.6*	*-2.8*	*0.4*	*14.1*	15.9
IE (A)	Clare	*103.3*	*30.0*	*9.9*	*9.7*	*17.6*	24.7
IE (B)	Wexford	*116.6*	*49.3*	*11.7*	*10.8*	*14.5*	24.2
ES (A)	L'Alcoià	*104.0*	*193.5*	*-3.9*	*1.9*	*52.4*	20.0
ES (B)	El Camp de Morvedre	*73.0*	*268.4*	*3.2*	*9.6*	*36.0*	20.0
GR (A)	Evrytania	19.3	10.4	-4.0	22.4	16.9	20.9
GR (B)	Achaia (part)	326.8	99.9	5.8	14.8	25.3	13.7
DE (A)	Rottal-Inn	119.6	93.3	5.2	9.8	34.8	19.2
DE (B)	Bitburg Prum	96.0	59.0	1.4	7.2	30.4	16.7
FI (A)	Keski Suomi (part)	265.6	16.0	3.3	6.7	29.2	20.2
FI (B)	Satakunta (part)	235.1	28.4	-4.3	6.8	34.2	21.3

Sources: Eurostat Regio database, except:
East Ayrshire, L'Alcoia and El Camp de Morvedre - AsPIRE Case Study Area Profiles (http://www1.sac.ac.uk/management/External/Projects/AspireExternal/Default.asp)
Ireland - Ireland Census 2002 (http://www.eirestat.cso.ie/Census/)

Table 3. The sectoral distribution of surveyed businesses in the 12 case study regions

	Region	Agriculture etc	Mining etc	Food Industry	Other Manufacturing	Electricity etc	Construction	Wholesale and retail	Hotels, Restaurants	Transport etc	Financial Services	Real Estate Etc	Other Services	Total
UK (A)	Shetland	1		5	17		1	2	5	3		1	15	50
UK (B)	East Ayrshire	1	1	4	17		1	2	1	4		1	18	50
IE (A)	Clare	1		2	11	7			7				22	50
IE (B)	Wexford	3		9	15	1			9	1		5	7	50
ES (A)	L'Alcoia			1	29		1	4	7				6	48
ES (B)	El Camp de Morvedre			7	17		2	5	4		1		13	49
GR (A)	Evrytania	1		8		1	1	21	8	1	2	1	6	50
GR (B)	Kalavryta			1		1	2	23	12		2		8	49
DE (A)	Rottal-Inn			1	24			6	6	2		9	2	50
DE (B)	Bitburg-Prum				24			4	10	2			10	50
FI (A)	Keski-Suomi			3	18	1		1	11			7	5	46
FI (B)	Satakunta			1	25			2	10	3		5	4	50
	Total	7	1	42	197	11	8	70	90	16	5	29	116	592

Table 4. Descriptive Statistics

Variables	Firms Located in Regions A		Firms Located in Regions B		All Firms	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Innovation rate	66.91	47.14	73.03	44.46	69.96	45.88
Size in employed labour units	26.20	51.12	14.09	29.47	20.17	42.16
Age in years since establishment	20.05	25.70	18.11	22.94	19.08	24.36
Sector of activity (0=manufacturing, 1=services)	0.56	0.50	0.54	0.50	0.55	0.50
Past Location (1=firm relocated from elsewhere)	0.17	0.37	0.21	0.41	0.19	0.39
Local Investments (% of invested capital raised locally)	65.98	45.09	68.37	43.94	67.17	44.50
Downstream (1=firm maintains formal relations with clients)	0.19	0.39	0.20	0.40	0.19	0.40
Sample Size	269		267		536	

Table 5. Estimates of Probit Models and of Average Innovation Activity Rates

Independent Variables	Model 1 (Regions A and B Pooled)		Model 2 (Regions A and B Pooled)		Model 3 (Regions A Only)		Model 4 (Regions B Only)	
	Coefficient Estimates	Marginal Effects	Coefficient Estimates	Marginal Effects	Coefficient Estimates	Marginal Effects	Coefficient Estimates	Marginal Effects
Constant	-0.198	-----	-0.303	-----	-1.387	-----	0.400	-----
	(0.243)		(0.237)		(0.408)**		(0.322)	
Region	-0.271	-0.087	-----	-----	-----	-----	-----	-----
	(0.129)**	(0.041)**						
Size	0.010	0.003	0.009	0.003	0.007	0.002	0.020	0.006
	(0.003)**	(0.001)**	(0.003)**	(0.001)**	(0.003)**	(0.001)**	(0.008)**	(0.002)**
Age	-0.007	-0.002	-0.007	-0.002	-0.007	-0.003	-0.010	-0.003
	(0.003)**	(0.001)**	(0.003)**	(0.001)**	(0.003)**	(0.001)**	(0.004)**	(0.001)**
Sector	0.003	0.001	-0.015	-0.005	-0.114	-0.038	0.100	0.029
	(0.137)	(0.044)	(0.137)	(0.044)	(0.214)	(0.072)	(0.190)	(0.055)
Past Location	0.330	0.098	0.348	0.104	0.278	0.089	0.369	0.098
	(0.176)*	(0.048)**	(0.175)**	(0.475)**	(0.276)	(0.082)	(0.242)*	(0.058)*
Local Investments	-0.003	-0.001	-0.003	-0.001	0.002	0.001	-0.007	-0.002
	(0.002)*	(0.000)*	(0.001)**	(0.000)**	(0.002)	(0.001)	(0.003)**	(0.001)**
Downstream	0.351	0.104	0.343	0.102	0.305	0.097	0.547	0.137
	(0.172)**	(0.046)**	(0.170)**	(0.462)**	(0.265)	(0.078)	(0.253)**	(0.054)**
Finland	1.096	0.256	1.060	0.252	1.951	0.388	0.649	0.153
	(0.240)**	(0.040)**	(0.237)**	(0.041)**	(0.386)**	(0.054)**	(0.352)**	(0.065)**
Spain	1.789	0.332	1.777	0.333	2.969	0.450	0.831	0.183
	(0.255)**	(0.030)**	(0.255)**	(0.299)**	(0.445)**	(0.046)**	(0.342)**	(0.057)**
Germany	1.00	0.244	1.000	0.244	1.624	0.352	0.726	0.169
	(0.212)**	(0.039)**	(0.210)**	(0.039)**	(0.342)**	(0.054)**	(0.302)**	(0.057)**

Ireland	1.424	0.306	1.429	0.307	2.480	0.435	0.777	0.178
	(0.227)**	(0.034)**	(0.226)**	(0.034)**	(0.391)**	(0.051)**	(0.300)**	(0.055)**
UK	0.963	0.237	0.958	0.237	1.850	0.376	0.387	0.100
	(0.205)**	(0.039)**	(0.204)**	(0.040)**	(0.337)**	(0.052)**	(0.242)	(0.068)
Model Statistics								
Log-Likelihood		-256.5		-258.70		-112.51		-128.36
$x^2_{d.f}$		142.2_{12}		137.8_{11}		116.5_{11}		54.6_{11}
ρ^2		0.22		0.21		0.34		0.18
% of correct predictions		78.0		78.2		81.4		77.5
Sample Size		536		536		269		267
Average Probability		0.698		0.699		0.670		0.729
		(0.066)**		(0.065)**		(0.095)**		(0.088)**

Note: Numbers in parentheses are standard errors[6]. One and two asterisks imply statistical significance at the 10% and 5% correspondingly. Marginal effects are estimated at sample means. Marginal effects for dummy variables are the differences of marginal effects at 0 and 1.

Table 6. Predicted Sample Proportions of Innovative Activity.

	Estimated Coefficients ($\widehat{\boldsymbol{\beta}}$) for:	
	Regions A	Regions B
Sample Averages ($\mathbf{x}$) for:		
Regions A	0.67	0.75
	(0.095)**	(0.219)**
Regions B	0.66	0.73
	(0.313)**	(0.088)**

Note: Numbers in parentheses are standard errors[7]. Two asterisks imply statistical significance at the 5% .

Table 7. Decomposition of the difference in average probabilities of innovative activity.

	Regions B-Regions A
Differences in means:	
$\widehat{y}^B - \widehat{y}^A$	0.06
Differences in coefficients:	
$\overline{P}(\boldsymbol{\beta}^{\mathbf{B}}, \mathbf{x}^{\mathbf{B}}) - \overline{P}(\boldsymbol{\beta}^{\mathbf{A}}, \mathbf{x}^{\mathbf{B}})$	0.07
Differences in characteristics:	
$\overline{P}(\boldsymbol{\beta}^{\mathbf{A}}, \mathbf{x}^{\mathbf{B}}) - \overline{P}(\boldsymbol{\beta}^{\mathbf{A}}, \mathbf{x}^{\mathbf{A}})$	-0.01

Table 8. Robustness of estimations by excluding one participating country.

	Country excluded from the analysis is:									
	Finland		Spain		Germany		Ireland		UK	
	Regions A	Regions B	Regions A	Regions B	Regions A	Regions B	Regions A	Regions B	Regions A	Regions B
Independent Variables										
Constant	-1.210	0.175	-1.472	0.459	-1.450	0.187	-1.258	0.728	-1.400	0.334
	(0.439)**	(0.334)	(0.4210**	(0.346)	(0.466)**	(0.346)	(0.440)**	(0.362)**	(0.444)**	(0.335)
Size	0.006	0.020	0.006	0.019	0.004	0.375	0.006	0.023	0.016	0.014
	(0.004)	(0.009)**	(0.003)*	(0.009)**	(0.003)	(0.015)**	(0.003)*	(0.009)**	(0.006)**	(.008)*
Age	-0.006	-0.010	-0.006	-0.012	-0.008	-0.009	-0.007	-0.101	-0.016	-0.006
	(0.003)**	(0.004)**	(0.004)*	(0.005)**	(0.004)**	(0.006)	(0.0040*	(0.004)**	(0.006)**	(0.005)
Sector	-0.142	0.109	-0.097	0.225	-0.077	0.128	-0.236	-0.063	-0.008	0.205
	(0.249)	(0.202)	(0.225)	(0.206)	(0.244)	(0.212)	(0.228)	(0.210)	(0.256)	(0.957)
Past Location	0.302	0.222	0.245	0.537	0.120	0.560	0.350	0.328	0.262	0.322
	(0.300)	(0.255)	(0.284)	(0.275)**	(0.340)	(0.291)**	(0.303)	(0.262)	(0.326)	(0.256)
Local Investments	0.001	-0.005	0.003	-0.009	0.003	-0.006	0.350	-0.010	0.003	-0.007
	(0.003)	(0.003)**	(0.002)	(0.002)**	(0.003)	(0.003)**	(0.303)	(0.003)**	(0.003)	(0.003)**
Downstream	0.375	0.597	0.296	0.679	0.245	-0.006	0.357	0.449	0.079	0.337
	(0.280)	(0.270)**	(0.265)	(0.272)**	(0.311)	(0.003)**	(0.289)	(0.286)	(0.303)	(0.294)
Finland	--------	--------	2.010	0.630	2.091	0.678	1.888	0.508	1.910	0.707
			(0.391)**	(0.363)**	(0.413)**	(0.357)*	(0.403)**	(0.363)	(0.405)**	(0.354)**
Spain	2.923	0.955	--------	--------	3.055	0.697	2.928	0.730	2.971	0.892
	(0.446)**	(0.346)**			(0.452)**	(0.356)*	(0.450)**	(0.349)**	(0.469)**	(0.346)**
Germany	1.544	0.762	1.643	0.833	--------	--------	1.566	0.683	1.656	0.769
	(0.345)**	(0.301)**	(0.344)**	(0.312)**			(0.348)**	(0.306)**	(0.355)**	(0.308)**
Ireland	2.400	0.783	2.520	0.794	2.649	0.707	--------	--------	2.410	0.865
	(0.393)**	(0.299)**	(0.393)**	(0.306)**	(0.411)**	(0.306)**			(0.406)**	(0.302)**
UK	1.793	0.354	1.865	0.474	1.964	0.265	1.806	0.371	--------	--------
	(0.341)**	(0.290)	(0.338)**	(0.296)	(0.349)**	(0.299)	(0.343)**	(0.293)		

Model Statistics										
Log-Likelihood	-87.671	-115.797	-105.770	-109.69	-86.52	-104.541	-99.201	-106.357	-84.012	-103.746
x_{10}^2	112.943	42.086	91.622	56.759	11.974	51.323	98.023	53.276	121.096	42.695
ρ^2	0.392	0.154	0.302	0.206	0.393	0.197	0.331	0.356	0.419	0.171
% of correct predictions	83.04	77.09	78.95	76.75	84.00	77.83	79.82	76.92	84.89	78.28
Sample Size	224	227	228	228	225	221	223	221	225	221
Sample Averages ($\mathbf{x}$) for:										
Regions A	0.657	0.735	0.619	0.732	0.672	0.740	0.620	0.714	0.658	0.758
	(0.095)**	(0.221)**	(0.109)*	(0.244)**	(0.099)**	(0.234)**	(0.109)**	(0.240)**	(0.092)**	(0.214)**
Regions B	0.642	0.708	0.612	0.706	0.669	0.723	0.613	0.710	0.638	0.746
	(0.330)*	(0.097)**	(0.314)*	(0.094)**	(0.340)*	(0.092)**	(0.323)*	(0.099)**	(0.340)**	(0.088)**
Differences in means: $\hat{y}^B - \hat{y}^A$	0.051		0.087		0.050		0.090		0.088	
Differences in coefficients: $\overline{P}(\boldsymbol{\beta}^{\mathbf{B}}, \mathbf{x}^{\mathbf{B}}) - \overline{P}(\boldsymbol{\beta}^{\mathbf{A}}, \mathbf{x}^{\mathbf{B}})$	0.066		0.094		0.054		0.097		0.108	
Differences in characteristics: $\overline{P}(\boldsymbol{\beta}^{\mathbf{A}}, \mathbf{x}^{\mathbf{B}}) - \overline{P}(\boldsymbol{\beta}^{\mathbf{A}}, \mathbf{x}^{\mathbf{A}})$	-0.015		-0.007		-0.004		-0.007		-0.020	

Note: Numbers in parentheses are standard errors. One and two asterisks imply statistical significance at the 10% and 5% correspondingly. Marginal effects are estimated at sample means.

Notes

[1] The final report, and several other project documents are available at http://www1.sac.ac.uk/management/External/Projects/AspireExternal

[2] Copus A K and Macleod M (Forthcoming) Taking a fresh look at peripherality, in Jones G and Leimgruber W, *Marginality in the Twenty-first Century: Theory and Recent Trends*, Ashgate, Aldershot.

[3] In order to test that the coefficient of the REGION dummy variable is zero we compute $LR = -2\left[\ln \hat{L}_1 - \ln \hat{L}_2\right]$ where $\ln \hat{L}_1$ and $\ln \hat{L}_2$ are the log likelihood statistics for models 1 and 2 respectively. LR follows a chi-squared distribution with one degree of freedom and its value of 4.42 is above the critical value o f 3.84 at the 5% level of significance which suggests that we do not accept the null hypothesis of the zero coefficient for the dummy variable REGION in model 1.

[4] In order to test homogeneity of the pooled sample as regards the two subgroups of firms in regions A and B we estimate a chi-square test $x^2 = 2\left[\left(\ln \hat{L}_A + \ln \hat{L}_B\right) - \ln L_{AB}\right]$ with number of subgroups minus 1 times the number of coefficients in the model and where $\ln \hat{L}_A$, $\ln \hat{L}_B$ and $\ln \hat{L}_{AB}$ are the log likelihoods for models 3, 4 and 2 respectively. The value of the test is 35.6 which is well above the critical value of 21.03 at the 5% level of significance and for 12 degrees of freedom. So we cannot accept the null hypothesis of homogeneity of the pooled sample (model 2) as regards the REGION dummy as a stratification variable.

[5] A report presenting and analyzing business characteristics of sampled firms may be found at the project's site:
(http://www1.sac.ac.uk/management/External/Projects/AspireExternal).

[6] Standard errors for predicted probabilities are computed using the delta linear approximation with the asymptotic variance of predicted probabilities being $Asy.Var[\hat{y}] = \left(\frac{1}{N}\sum_{i=1}^{N}\hat{\phi}_{i\boldsymbol{\beta}}\right)' \hat{\boldsymbol{\Omega}}_{\boldsymbol{\beta}} \left(\frac{1}{N}\sum_{i=1}^{N}\hat{\phi}_{i\boldsymbol{\beta}}\right)$ where $\hat{\phi}_{i\boldsymbol{\beta}}$ is the gradient of an observation i with characteristics captured by the row vector $\mathbf{x_i}$ and with respect to the vector of estimated coefficients $\hat{\boldsymbol{\beta}}$ and $\hat{\boldsymbol{\Omega}}_{\boldsymbol{\beta}}$ is the estimate of the covariance matrix of the $\hat{\boldsymbol{\beta}}$ vector from the respective probit procedure.

[7] Standard errors for predicted probabilities when a set of coefficients from one probit procedure is used on the characteristics of another set of observations follows the formula provided in appendix 2 of Gomulka and Stern (1990). For example, the asymprotic variance of $\overline{P}\left(\boldsymbol{\beta}^{\mathbf{A}}, \mathbf{x}^{\mathbf{B}}\right)$ is:

$$Asy.Var\left[\overline{P}\left(\boldsymbol{\beta}^{\mathbf{A}}, \mathbf{x}^{\mathbf{B}}\right)\right] = \frac{1}{N_B}\sum_{i=1}^{N_B}\left(\hat{\phi}_{i\boldsymbol{\beta}^{\mathbf{A}}}\right)^2 - \left(\frac{1}{N_B}\sum_{i=1}^{N_B}\hat{\phi}_{i\boldsymbol{\beta}^{\mathbf{A}}}\right)^2 + \left(\frac{1}{N_B}\sum_{i=1}^{N_B}\hat{\phi}_{i\boldsymbol{\beta}^{\mathbf{A}}}\right)' \hat{\boldsymbol{\Omega}}_{\boldsymbol{\beta}^{\mathbf{A}}} \left(\frac{1}{N_B}\sum_{i=1}^{N_B}\hat{\phi}_{i\boldsymbol{\beta}^{\mathbf{A}}}\right)$$

where N_B is the sample size of firms in regions B, $\hat{\phi}_{i\boldsymbol{\beta}^{\mathbf{A}}}$ is the gradient of an observation i in regions B with characteristics captured by the row vector $\mathbf{x}_{\mathbf{i}}^{\mathbf{B}}$ and with respect to the vector of estimated coefficients $\hat{\boldsymbol{\beta}}^{\mathbf{A}}$ from the probit procedure for firms in regions A and $\hat{\boldsymbol{\Omega}}_{\boldsymbol{\beta}^{\mathbf{A}}}$ is the estimate of the covariance matrix of the $\hat{\boldsymbol{\beta}}^{\mathbf{A}}$ vector from the probit procedure for firms in regions A. Fairlie (2003) proposes a similar use of the delta approximation procedure to estimate standard errors. Due to the almost equal sample sizes of firms in regions A and B, when Fairlie's method was applied on our data , almost the same statistically significant results were derived with less than 100 random draws.