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Explaining Spatial Variation in Business Performance in Great Britain*

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Abstract

Labour productivity rates are known to vary across UK regions. Although some empirical studies seek to explain the source of these differences using aggregate, regional data we argue that this may be inappropriate because labour productivity rates are firm-specific. This paper employs cross-sectional regression analysis and British, firm-level data to identify empirically whether firm-level labour productivity rates are affected by factors that vary spatially. It focuses in particular on a measure of 'economic potential' based on a gravity-type model of economic potential. Initial estimates suggest that economic potential is important but its impact diminishes with the introduction of further explanatory variables. Nevertheless, even once interaction terms are included the effect of economic potential remains important. It suggests the clear need to take account of space in firm-level regressions.

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1. Introduction

Issues of competitiveness and productivity at a regional level have increasingly been a focus for academic and policy concern. As Gardiner *et al* (2004) observe, differentials in competitiveness and productivity have been a focus for policy concern on grounds of both equity and social cohesion. Increasingly as well, the policy goal of reducing differentials, specifically by raising the competitiveness of the less buoyant regions, has been seen as a key to raising overall levels of productivity at a national or European level and closing the gap on competing territories in a global context.

Harris and Li (2005) found evidence that spatial agglomeration is associated with a higher probability of exporting which is in turn linked to higher productivity. Work by Boddy *et al.* (2005) also started to explore the effects of 'peripherality' as a measure of spatial factors that might impact on productivity and found that peripherality accounted for a significant proportion of the productivity gap between the regions and countries of Great Britain, having already taken into account factors including capital stock, skills, foreign ownership and a range of other variables.

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This paper seeks to extend this analysis of spatial factors by building a measure of economic potential based on a gravity-type model into an establishment-level analysis of productivity across Great Britain. We then seek to identify whether this variable is an important factor in determining the labour productivity of plants across Great Britain using cross-sectional regression analysis. Our results suggest that the importance of this economic potential is overstated as it is correlated with several other contributory factors; nevertheless it remains important even after other factors have been taken into account.

The rest of this paper is structured in the following way. The next section presents a review of the literature which is followed in Section 3 by the model specification. Details of the data used in the econometric part of this study are presented in Section 4. The results are presented in Section 5. Conclusions are presented in Section 6.

2. Survey of the theoretical and empirical literature

In the UK, the government has specifically emphasized the importance of the regional dimension to its central economic objectives (HM Treasury, 2001; HM Treasury, 2004; Department of Trade and Industry, 2004)[1]:

> The government's central economic objective is to achieve high and stable levels of growth and employment. Improving the economic performance of every country and region of the UK is an essential element of that objective, firstly for reasons of equity, but also because unfulfilled economic potential in every region must be released to meet the overall challenge of increasing the UK's long-term growth rate (HM Treasury, 2001, v)

It notes the 'significant and persistent differences in economic performance between and within the UK regions' and goes on to argue that:

> This is why any regional economic policy must be focused on raising the performance of the weakest regions rather than simply re-distributing existing economic activity. Real economic gain for the country as a whole will only come from a process of 'leveling up'. (ibid)

The English Regional Development Agencies have been specifically charged with the policy goal of closing the productivity gap and this has also been a key policy goal in both Wales and Scotland.

Similarly, at an EU level, regional competitiveness and productivity differentials have been seen as particularly significant both in terms of closing the gap between the EU, the USA and other major competitors in a global context but also specifically in relation to objectives of social cohesion at European scale – particularly in the context of monetary union and the enlargement of the EU to include a wide range of less economically buoyant regions and nation states (Gardiner et al, 2004). The Lisbon Agenda in 2000 had set out the goal that Europe should become 'the most dynamic and competitive knowledge-based economy in the

[1] Public Service Agreement targets set in 2004 include as a joint commitment for HM Treasury, the Office for the Deputy Prime Minister and the Department for Trade and Industry the target to: 'Make sustainable improvements in the economic performance of all English regions by 2008 and over the long term reduce the persistent gap in growth rates between the regions, demonstrating progress by 2006'. (HM Treausury, 2004).

world by 2010'. The 2004 *European Competitiveness Report* (European Commission, 2004a) included a specific focus on regional aspects of competitiveness and productivity across the EU member states. This drew in part on a major study on the factors impacting on regional competitiveness commissioned by the Regional Policy Directorate of the EU (2003). Thus, the *Third Report on Economic and Social Cohesion* argued that:

> If the EU is to realize its economic potential, then all regions wherever they are located, whether in existing member states or in the new countries about to join, need to be involved in the growth effort … the cost of not pursuing a vigorous cohesion policy to tackle disparities is, therefore, measured not only in terms of loss of personal and social well-being but also in economic terms, in a loss of potential real income and higher living standards … strengthening regional competitiveness throughout the Union … will boost the growth potential of the EU countries as a whole to the common benefit of all. (European Commission, 2004b, vii-viii)

Recognising lack of progress against the highly ambitious goals set by the original Lisbon Agenda the latter was relaunched in 2005 in the form of the Common Lisbon Agenda with the Commission proposing that programmes supported by the Structural Funds and Cohesion Fund target investments in knowledge, innovation and research capacities as well as improved education and vocational training. The need to boost the productivity and competitiveness of the less economically buoyant regions in the EU was again stressed.

At the same time there has been a growing focus in the academic literature on issues around regional competitiveness and productivity (See *Regional Studies*, 2004) and the competitiveness of different places. Much of this debate has focused on definitions of competitiveness itself; whether and in what ways it makes sense to see regions or cities competing one with another; the bases for such competition; and how differences in competitiveness might best be defined and measured (Begg, 1999, 2002; Boddy, 2000; Camagni, 2002; Krugman, 1990; Porter, 1992, 1998, 2001a, 2001b; Regional Studies vol 38(9), 2004; Urban Studies, 1999). There has also been considerable debate around conceptual issues and alternative accounts of regional productivity differentials and regional productivity growth (Boschma, 2004; Budd and Hermis, 2004; Gardiner et al, 2004). Gardiner et al, for example, summarizing a wide-ranging literature, distinguish between neo-classical growth theory emphasizing differences in factor endowments, capital/labour ratios and technology; endogenous growth theory emphasizing technology, the knowledge-base and knowledge workers; and the new economic geography or 'spatial economics', emphasizing the significance of spatial agglomeration, clustering and specialization as the basis for increasing returns.[2]

The UK series of UK Treasury reports on productivity in the UK, drawing on a wide range of evidence from the academic and policy literature, identify five key drivers of productivity and productivity differentials across space – skills, investment,

[2] A more extended review is presented in the longer report (Cambridge Econometrics et al., 2003) on which this particular article draws.

competition, innovation and enterprise. There is considerable evidence as to the contribution of skills and human capital acquired both through education and training and work experience to levels of productivity (Romer, 1986, 1990; Lucas, 1988; Lau and Vaze, 2002). Human capital is central to the endogenous growth theory and the new economic geography (Mankiw et al, 1992; Barro and Sala-i-Martin, 1994) whilst other studies have emphasised the links between skills and innovative capacity (Nelson and Phelps, 1966; Aghion and Howitt, 1998).

Investment increases labour productivity by increasing the capital stock that workers can utilise. Indirect effects also occur where investment results in labour gaining new skills and becoming more efficient (HM Treasury, 2006). Investment includes both physical capital including ICT, infrastructure and public sector investment all of which can impact on productivity levels. Empirical studies have demonstrated the effects of capital intensity in general (Baumol et al, 1989; Grossman and Helpman, 1994) and specifically of ICT investment (Jorgenson, 2001; Sadun, 2005).

Exposure to competition is seen as driving up productivity by encouraging firms to adopt measures to increase competitiveness and efficiency. Competition may have the effect of driving less competitive firms out of business or reducing their market share – more competitive firms may replace them or expand market share (Disney et al, 2003). Competition can also bring exposure to new ideas, innovation and business practice. Competition may be among domestic firms but may also arise through exposure to foreign multi-nationals or in export markets (Barnes and Haskell, 2000).

Innovation has been widely linked to increased productivity both through direct gains from investment in innovation or R&D or spillover effects from different forms of innovation building on each other or spillovers from other firms or exposure to innovation in export markets for example (Cameron, 2003; Harris and Li, 2005, 2007).

Finally, enterprise, the final Treasury driver, commonly seen in terms of new firm formation and growth has been seen as associated with productivity growth and competitiveness. New and growing firms can be associated with new technologies, innovative work practices and entrepreneurial drive. Entry of new firms can also increase competition drive out poor performers and reallocate production to more productive businesses (Jovanovic, 1982; Disney et al, 2003).

There is also growing evidence on the role of spatial factors per se on productivity and competitiveness over and above the impact of other factors. These include the positive impacts of spatial agglomeration in the form of access to markets; large pools of labour with a spread of skills; and specialist suppliers, sub-contractors and services. Clustering in space can also promote knowledge spill-overs and innovation. It may also lead to greater competitive pressures with knock on effects on innovation and productivity.

Rice and Venables (2004) examine the determinants of spatial productivity differentials at the level of NUTS 3 regions across the UK. Using income per worker as a proxy for productivity, they initially demonstrate that around a third of productivity differentials are accounted for by the occupational composition and therefore, they assume, variation in pay levels. This suggests that some two-thirds of spatial variation in earnings is actually attributable to differences in productivity as such and to the factors that determine productivity levels. Drawing on recent theories from new economic geography they then relate productivity differentials to a

measure of economic mass – constructed on the basis of drive-times and the size of the working-age population in relation to each region. This represents one of the few recent applications of a gravity-model type approach to the impacts of relative location on productivity differentials. They find a significant effect of proximity to economic mass on productivity – greatest within 40 minutes drive time and tapering off quite steeply to zero beyond around 80 miles. They suggest that doubling the economic mass associated with a particular region increases productivity by 3.5%. Overall, just over a third of the predicted spatial variation in UK productivity is found to be attributable to economic mass. This compares with some 46% that is attributable to levels of qualification in the working age population or to other 'region specific' factors.

3. Model specification

Production functions

In modelling regional productivity differentials, we assume, as very commonly used, a Cobb Douglas production function:

$$Y = AK^{\beta 1}L^{\beta 2} \qquad [1]$$

where K is capital stock, Y gross value added at factor cost (GVAFC) and L is the quantity of labour. A represents efficiency factors which we model as a function of all the factors that may impact on productivity and output, such as locational variables, ownership, skill variables, etc.

We divide both sides by L to give labour productivity as the dependent variable to be explained, convert to logs and augment the model to include a range of explanatory variables. This gives us:

$$\text{Ln}(y/l) = \beta_0 + \beta_1 \ln(k)_i + \beta_2 \ln(l)_i + \beta_3(\text{pot})_i + + \beta_4(s1)_i + \beta_5(s2)_{i\,+} + \beta_6(n)_{I\,+} \text{Industry}_i + u_i \qquad [2]$$

where pot is economic potential at the location of plant I (described below), s1 the proportion of the local labour force with higher level qualifications, s2 the proportion with no formal qualifications, n is the number of plants in the business of which plant i is a part, industry is industrial sector, and u is an error term which we assume is normally distributed and well-behaved. The measure of productivity used is output per unit of labour. Labour productivity per se depends upon the level of capital stock and vice versa. But having estimated equation (2) it is possible to find estimates of labour productivity for a given level of capital stock. In addition any event, other than increasing labour or capital, which impacts positively on total output will also increase both labour and capital productivity.

The model thus takes into account key drivers of productivity including capital stock and skills. It also takes account of differences in productivity that might reflect industrial structure. The economic potential variable is admittedly complex. It is likely to pick up a range of effects including both levels of competition and the effects of agglomeration as these vary over space. In terms of the other Treasury drivers, the ARD does not provide any direct measure of innovation. Nor is there any obvious measure of enterprise as such – defined by the Treasury in terms of new business start-ups.

Economic potential

The economic potential variable, included in the model as set out above, measures the potential interaction between one place and every other place in the set of n places, defined for each place i as:

$$pot_i = (\sum pi*pj/dij^2)/n \qquad [3]$$

ie the average (for all other places) of p_i*p_j/dij^2, where p_i is the population at place *i*, p_j, that at place *j*, and d_{ij} is the distance between place *i* and place *j*. Population (pi) is measured at the level of the administrative area in which each establishment is located; p_j is the population of every other administrative area in Great Britain; d_{ij} is represented by the straight-line distance between the centroids of each administrative area. This provides an index of economic potential for each administrative area in the country as a whole. This as then linked to establishments by postcode. The index of economic potential captures a number of possible effects on productivity. From the perspective of spatial economics or the new economic geography, large agglomerations of population, labour and firms provide ready access to markets; large pools of labour with a spread of skills; specialist suppliers, sub-contractors and services; and greater possibilities for spillovers, knowledge exchange and innovation. The index of economic potential is likely to pick up the combined effects of these different strands of broadly defined agglomeration effects. This is on top of any more straightforward cost-penalties of peripherality and doing business at a distance from markets and suppliers.

4. Data

Factors influencing productivity ultimately act by influencing the operational performance of firms. Analysing business performance at the firm level overcomes the shortcomings of working with aggregate data, in particular by providing an unambiguous association between output and the workforce responsible for generating it. In the analysis below we use the establishment level data held by the Office for National Statistics in the Annual Respondents Database (ARD) which brings together a wide range of data relating to individual business units (ONS, 2002). As a data source, this has many advantages over aggregate-level data on productivity and other variables, not least the fact that it allows an extensive set of variables to be analysed at the level of the individual establishment as well as the sheer size of the data set.

We then link to this establishment data two other sources of data. These include skills data derived from the 2001 Census of Population. We include the proportion of the local labour force with higher level qualifications (defined as NVQ 4 and above and the proportion of the labour force with no formal qualifications. The effect of skill level is measured against a benchmark of the proportion with medium level qualifications (NVQ1-3). Skill levels are measured at the level of the administrative area (local authority district) in which each establishment is located and linked to establishments by postcode.

One issue with the ARD is the level at which the data are collected: we use the establishment. However, different establishments have different numbers of plants and to control for this we include as an additional variable the number of plants within the establishment in order to take account of any impacts this may have. We use GVA per employee as the measure of productivity.

5. Results

Analyses involved maximisation of the likelihood function for each estimation by means of OLS estimation methods using STATA v9.0. All standard errors were corrected for heteroskedasticity using White's methodology. In each regression the number of firms is equal to 24060. The regression results are reported in three stages on Tables 1-3.

Table 1 presents the results of the OLS estimates that employ the full sample of plants. We include *unit* which corresponds to the number of plants within the establishment. This is in accordance with much of the literature that employs this data set and it captures the effects of having more than one registered part of the production process, be it a plant in a different location or a different sub-section of the establishment which might be located on the same geographical site. To take this explicitly into consideration each regression includes the variable which is equal to 1 if the plant is the only plant in the establishment. In all other cases this variable adopts the number equal to the total number of plants for the whole establishment. It may well be the case that there are decreasing returns to scale due to administrative and managerial problems associated with establishments that have more than one plant.

The results are presented in three stages. Some policy makers first examine the industrial background of an economy when investigating labour productivity; accordingly the influence of economic potential on labour productivity is identified once the industrial background of the plant is identified along with the number of plants within the establishment in column 1. Economic potential has a statistically significant enhancing effect on labour productivity and there are clear and statistically significant industrial effects of industrial composition. We can be 99% sure that this positive coefficient of 0.077 did not occur by chance.

A second stance is to identify the influence of labour and capital on productivity a la Solow and Swan type neoclassical growth theory. The model is based on the traditional Cobb-Douglas production function whereby output per employee is driven by employment and capital. Such results are presented in column 2. Firm specific capital stock and labour supply has the expected coefficient magnitudes and are also statistically significant at the 99% level. Firms with greater amounts of capital have higher rates of productivity per employee. Of use for policy makers is the educational background of the labour force. Businesses in areas with a higher proportion of the workforce with low-range skills experience lower labour productivity rates. Again gravity has an enhancing effect on labour productivity, although using this type of modelling approach the economic potential effect appears to be slightly smaller at 0.061 although still very strongly statistically significant.

Column 1 could be criticised for not taking into account the capital stock and the labour force of the firm while column 2 could be criticised for not considering the industrial background of the firm. To overcome these criticisms we estimate the model using both the industrial background and the growth accounting type approaches. This time we also include the effect of private ownership and these results are presented in column 3.

As the coefficients for the explanatory variables are all affected by the inclusion of the previously excised explanatory variables, there is some evidence to suggest that these variables are correlated. This is not surprising however; for example consider a firm operating in the hotel sector – such a firm is probably going

to be dominated by workers with relatively low educational qualifications and probably also with a relatively small labour force size. Nevertheless, it is of interest to note that once the industrial background is taken into account high skills now have a statistically significant and enhancing effect on labour productivity as well as low skill workers reducing labour productivity, albeit with a diminished magnitude. However, the focus of this research is the stability and the importance of the economic potential effect and the economic potential effect remains statistically significant at the 99% level and positive with a magnitude of 0.038. However this effect has diminished with the inclusion of the other explanatory variables suggesting that either the actual effect of economic potential was over estimated and over-emphasised or that the effect of economic potential on labour productivity is highly correlated with other factors.

Table 1: Full Sample

	1	*2*	*3*
Economic potential	0.077*** (0.011)	0.061*** (0.009)	0.038*** (0.009)
Capital		0.424*** (0.005)	0.462*** (0.005)
Employment		-0.496*** (0.007)	-0.513*** (0.007)
High skills		0.051 (0.043)	0.099** (0.042)
Medium skills	*Control variable*		
Low skills		-0.299*** (0.061)	-0.156*** (0.059)
Private			0.472*** (0.038)
Manufacturing	0.135*** (0.031)		-0.188*** (0.028)
Construction	0.145*** (0.036)		0.210*** (0.030)
Wholesale and Retail	-0.169*** (0.032)		-0.011 (0.027)
Hotels and Catering	-0.783*** (0.038)		-1.136*** (0.033)
Transport	0.250*** (0.045)		-0.192*** (0.037)
Real Estate	0.057* (0.034)		0.236*** (0.028)
Social Work	-0.633*** (0.045)		-0.382*** (0.036)
Other sectors	*Control variable*		
Units	1.187*** (0.009)	0.658*** (0.009)	0.617*** (0.009)
R^2	0.508	0.654	0.685
F test	2209.40***	6720.43***	3460.96***

Notes: In all estimates, the dependent variable is *labour productivity* and the sample size is 24060. All regressions are estimated using OLS and have robust standard errors. Values in parentheses are standard errors. *, ** and *** signify significance at the 10%, 5% and 1% level respectively. Constants omitted as per ONS requirements. Source: ONS.

Qualitatively similar results are presented for those establishments with are comprised of only one plant; see Table 2.

These results are of interest because it indicates that part of the effect of economic potential on labour productivity is correlated with other explanatory variables. There are two main ways to investigate such special effects further. The first is to employ interaction terms between the explanatory variables and economic potential, while the second line of investigation would be to employ a spatial lag model. Given that the UK's Office for National Statistics Business Data Linking secure lab is currently not set up for estimation of spatial lag models using GeoDA

software, the former stance is adopted. The results of these estimations are presented in Table 3.

Table 2: Single Plant Firms Only

	1	*2*	*3*
Economic potential	0.074*** (0.012)	0.059*** (0.011)	0.038*** (0.010)
Capital		0.304*** (0.007)	0.347*** (0.008)
Employment		-0.318*** (0.009)	-0.337*** (0.009)
High skills		0.064 (0.051)	0.116** (0.050)
Medium skills	*Control variable*		
Low skills		-0.346*** (0.073)	-0.205*** (0.070)
Private			0.610*** (0.051)
Manufacturing	0.209*** (0.032)		-0.160*** (0.033)
Construction	0.237*** (0.036)		0.227*** (0.034)
Wholesale and Retail	-0.043 (0.035)		0.014 (0.033)
Hotels and Catering	-0.616*** (0.039)		-0.998*** (0.038)
Transport	0.199*** (0.047)		-0.174*** (0.043)
Real Estate	0.078** (0.037)		0.179*** (0.034)
Social Work	-0.517*** (0.046)		-0.421*** (0.042)
Other sectors	*Control variable*		
R^2	0.038	0.184	0.249
F test	137.34***	425.80***	299.43***

Notes: In all estimates, the dependent variable is *labour productivity* and the sample size is 16510. All regressions are estimated using OLS and have robust standard errors. Values in parentheses are standard errors. *, ** and *** signify significance at the 10%, 5% and 1% level respectively. Constants omitted as per ONS requirements. Source: ONS.

Of immediate interest is that economic potential remains statistically significant, suggesting that even after the interaction of economic potential and explanatory variables has been taken into account, there is still an effect of economic potential on labour productivity, suggesting that not all economic potential effects are correlated with the other explanatory variables.

Statistically significant interaction terms are presented in bold. These interaction terms are of particular interest. For instance, the effect of larger amounts of firm-specific capital on labour productivity is greater in areas where economic potential is larger. It suggests the enhancing capital accumulation in city areas will benefit labour productivity. Also of interest is that a greater abundance of low skills does not diminish labour productivity in places where economic potential effects are high to the same extent when they are low. This should influence policy makers if they are driven to increase labour productivity because the returns to diminishing the proportion of the workforce with only low skills are spatially dependant on the economic potential effect.

Also of interest is that the construction has a less enhancing effect on labour productivity in core – high economic potential – areas. The same can be said for firms operating in the wholesale and retail sector. Although the construction, wholesale and retail and hotels and catering dummies remain statistically significant,

the introduction of the interaction terms makes all other sector dummies insignificant. One reason for this is that their effect might have already been captured by the introduction of other explanatory variables, and in particular those variables which capture interaction.

Table 3: Interaction with Economic Potential

	Full Sample	*Single Plant Firms*
n	24060	16510
Economic potential	**0.342** (0.172)**	**0.421** (0.197)**
Capital	0.401*** (0.035)	0.295*** (0.047)
Capital * Economic potential	**0.011* (0.006)**	0.009 (0.009)
Employment	-0.375*** (0.043)	-0.200*** (0.059)
Employment * Economic potential	**-0.026*** (0.008)**	**-0.025** (0.011)**
High skills	-0.054 (0.283)	-0.226 (0.327)
High skills * Economic potential	0.033 (0.051)	0.067 (0.059)
Medium skills	*Control variable*	
Low skills	-1.167*** (0.359)	-1.293*** (0.420)
Low skills * Economic potential	**0.195*** (0.066)**	**0.209*** (0.077)**
Private	0.196 (0.238)	0.587* (0.301)
Private * Economic potential	0.051 (0.044)	0.004 (0.056)
Manufacturing	0.090 (0.179)	-0.050 (0.209)
Manufacturing * Economic potential	-0.051 (0.033)	-0.020 (0.039)
Construction	0.639*** (0.192)	0.475** (0.208)
Construction * Economic potential	**-0.079** (0.036)**	-0.046 (0.039)
Wholesale and Retail	0.308* (0.166)	0.014 (0.197)
Wholesale and Retail * Economic potential	**-0.059* (0.031)**	0.001 (0.037)
Hotels and Catering	-0.849*** (0.206)	-0.993*** (0.234)
Hotels and Catering * Economic potential	-0.051 (0.039)	0.001 (0.044)
Transport	0.193 (0.230)	0.050 (0.279)
Transport * Economic potential	-0.070 (0.043)	-0.041 (0.053)
Real Estate	0.241 (0.175)	0.005 (0.209)
Real Estate * Economic potential	-0.001 (0.032)	0.032 (0.038)
Social Work	-0.061 (0.244)	-0.512* (0.281)
Social Work * Economic potential	-0.059 (0.046)	0.018 (0.054)
Other sectors	*Control variable*	
Llunit	0.770*** (0.060)	-
Llunit * Economic potential	0.021*** (0.001)	-
R^2	0.686	0.251
F test	1811.670***	159.94***
LR test for collective variable deletion of composite variables	**5.25*** **	**3.28*** **

Notes: In all cases, the dependent variable is *labour productivity*. All regressions have robust standard errors. Values in parentheses are standard errors. *, ** and *** signify significance at the 10%, 5% and 1% level respectively. Constants omitted as per ONS requirements. Source: ONS.

6. Conclusion

The purpose of this paper was to investigate whether the effect of economic potential on labour productivity is stable and whether the economic potential effect can be explained away through the use of other explanatory variables. Our results

suggest that although the economic potential effect is correlated with some spatially dependant effects, the economic potential effect remains stable and statistically significant, as do the importance of other policy relevant variables. Further work could usefully explore in more detail the nature of the spatial decay function including the overall shape of the function and possible existence of thresholds or discontinuities. Nor, in the current work did we investigate the impacts of London and the extent to which the importance of location relative to the national capital had any disproportionate effect. It could also add to our understanding of spatial effects if a specific measure of agglomeration effects were included alongside the distance or relative location effects which are implicitly captured by the economic potential-model.

From a policy perspective, the significance and stability of economic potential as captured by the economic potential model formulation, emphasises the importance of the combination of location and economic mass. Peripherality carries a significant penalty in terms of productivity and economic competitiveness. In policy terms this might suggest the importance of access, transport infrastructure and mobility more generally including e-mobility (provision and use of internet and web applications etc). This is relevant from an equity perspective, emphasising the need to close the gap between less prosperous and more prosperous parts of the EU. It also, however, points to the fact that promoting investment and economic development in those parts of a country with relatively high levels of economic potential might yield higher rates of return on public sector investment and policy intervention.

Other findings point to the positive impact of higher level skills and the negative impact of lower level skills. This suggests the positive benefits to be gained from policy intervention to boost higher level skills (in UK terms at NVQ level 4 and above) and to reduce the proportion of the labour force which lacks any formal qualification. The emphasis in the UK and other EU countries on developing the skill base for the knowledge-based economy would appear to be supported by the current findings. Significantly as well, the nature of the interaction between economic potential and low skills suggests that concentrations of low-skilled labour have a stronger negative effect on productivity in more peripheral areas – and that from a policy perspective, addressing such skill deficiencies is particularly important in such areas. The demonstrated positive impacts of capital stock on productivity are line with expectations. Possibilities of policy leverage over this particular factor are, however, limited.

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Appendix

Table A1: Definitions of variables

Variable Name:	Definition:
LGVAFCpw	Log of Gross value added at factor cost per worker at the plant level. Source: ARD2 database
Llunit	Log of the number of plants in the establishment. Source ARD2 database
Employment	Log of the number of workers the plant employs. Source: ARD2 database
Capital	Log of the capital stock of the plant. Source: ONS
High skills	Log of the proportion of the district's working age population with either a first degree, higher degree, NVQ levels 4 and 5, HNC, HND, qualified teacher status, qualified medical doctor, qualified dentist, qualified nurse, midwife or heath visitor. Source: Census, 2001
Medium skills	The proportion of the district's working age population with less than high skills but more than low skills. This is a skill control variable. Source: Census, 2001
Low skills	Log of the proportion of the district's working age population with no formal qualifications. Source: Census, 2001
Private	= 1 if the plant is privately owned = 0 otherwise. Source: ARD2 database
Construction	= 1 if the firm operates in the construction industry = 0 otherwise. Source: ARD2 database
Wholesale / Retail	= 1 if the firm operates in the wholesale or retail industries = 0 otherwise. Source: ARD2 database
Hotel / Catering	= 1 if the firm operates in the catering industry = 0 otherwise. Source: ARD2 database
Transport	= 1 if the firm operates in the transport industry = 0 otherwise. Source: ARD2 database
Real Estate	= 1 if the firm operates in the real estate industry = 0 otherwise. Source: ARD2 database
Social Work	= 1 if the firm operates in the social work industry = 0 otherwise. Source: ARD2 database
Manufacturing	= 1 if the firm operates in the manufacturing industry = 0 otherwise. Source: ARD2 database
Other Sectors	= 1 if the firm does not operate in any of the sectors accounted for above = 0 otherwise. Source: ARD2 database. This is an industry control variable