Regional Productivity Differentials: Explaining the Gap

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Abstract:

Issues of productivity and competitiveness at a regional level have increasingly been a focus for both academic and policy concern. Significant and persistent differences in productivity are evident both in the UK and across Europe as a whole. This paper uses data relating to individual business units to examine the determinants of regional productivity differentials across British regions. It demonstrates that the substantial differences in regional productivity can be explained by a fairly limited set of variables. These include industry mix, the capital employed by the firm, business ownership and the skills of the local labour force. Also important are location-specific factors including travel-time from London and population density. Taken together, these factors largely explain regional productivity differentials. The analysis extends those studies that have identified but not quantified the role of different 'productivity drivers' in a systematic fashion or that have focused on only a limited set of drivers. It has important policy implications particularly in relation to the role of travel time and possible effects of density and agglomeration.

JEL Classifications:

Keywords: Regional competitiveness; Productivity; UK; Regional development; business-data analysis;

Acknowledgements: We wish to acknowledge the help of Felix Ritchie and his colleagues at the Office of National Statistics in both London and Newport. Any errors are the authors' responsibility.

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INTRODUCTION

Issues of competitiveness and productivity at a regional level have increasingly been a focus for academic and policy concern, as evidenced by the recent special issue of Regional studies on 'Regional Competitiveness' *Regional Studies* (2004). 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 between competing territories in a global context. 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 'levelling 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 2003 *European Competitiveness Report* (European Commission, 2003) 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, 2004, vii-viii)

At the same time there has been a growing focus in the academic literature on issues around regional competitiveness and productivity, and what GARDINER et al (2004) have termed 'territorial' or 'place competitiveness' at different scales including, as noted, the earlier special edition of Regional Studies.[2] 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 emphasizing the significance of spatial agglomeration, clustering and specialization as the basis for increasing returns.[3]

They also suggest that competitiveness in a regional context is an 'aggregative' notion based on a wide variety of possible sources of competitiveness. In this context, the common headline measure of economic performance in the form of output per head of population is a combination of workforce factors (particularly the employment rate) and actual labour productivity. Labour productivity and the employment rate are measures of what they term 'revealed competitiveness'. On their own, however, they reveal little of the actual sources of competitive advantage as such (GARDINER et al, 2004,1049).

Alternative conceptual perspectives have in turn informed attempts to measure different aspects of competitiveness and to identify those factors which might account for differences in competitiveness and productivity across different territorial units. This has included wide-ranging sets of indices of competitiveness, innovation and economy performance, again at both an EU and UK level. For the EU, the *2003 European Innovation Scoreboard* assembled information on a range of 'innovation indicators' at a regional (NUTS 2) level across the EU, together with data on per capita GDP. It derived summary indicators of innovation performance and regional league tables based on these. The study stopped short of statistical analysis but suggested that such indicators could account to a considerable extent for variations in competitiveness as measured by productivity. For the UK, *Regional Competitiveness and the State of the Regions* (DTI, 2004) gathered together a wide-ranging set of indicators 'intended to give a balanced picture of all the statistical information relevant to regional competitiveness' and to illustrate 'the factors that contributed to regional competitiveness'.[4] As with the EU study, however, there was no attempt at statistical analysis or to relate indicators of competitiveness to factors that might account for differences in competitive performance.

The UK Treasury reports on Productivity in the UK (HM TREASURY, 2000, 2001) drew widely on the evidence base of existing academic and policy literature in order to identify both productivity differentials and those factors that might account for such differences. Based on the available evidence, the Treasury identifies five key

'drivers' of productivity differentials: skills, investment, innovation, enterprise and competition. In the report on 'the regional dimension' (HM TREASURY, 2001), information is presented under each of these headings to demonstrate regional disparities in the supposed drivers of productivity differentials – qualifications, capital expenditure in manufacturing, R&D expenditure, business start-ups etc. There is no attempt, however, specifically to link differences in productivity to differences in these various indicators, nor to establish the relative importance of the various indicators and drivers. Each driver is in turn claimed to be a 'key determinant', 'key factor' or simply a 'key driver'.

There is, in practice, a relative lack of empirical analysis that has sought to identify those factors that are associated with differences in regional competitiveness and productivity or to assess their relative importance. Much of the empirical evidence base including that on which the Treasury draws consists of studies focusing on the role of particular factors in isolation. As already noted studies that have assembled a more comprehensive set of indicators have generally stopped short of statistical or econometric analysis, with some important exceptions. For the EU, CAMBRIDGE ECONOMETRICS et al (2003) drew on a comprehensive data-base for regions at NUTS 2 level across Europe to analyse productivity differentials, evidence for convergence in levels over time and to relate productivity differentials to a range of possible explanatory variables. Simple pair-wise correlations with productivity (measured as output per hour) suggested positive relationship with R&D expenditure, degree of specialization in high tech sectors and the proportion of the population in higher education although all correlations were relatively weak. There was no apparent relationship with levels of investment, level of employment in R&D, length of motorway or volume of rail freight. There was however a strong correlation between level of productivity in a region and that in other nearby regions. Multivariate analysis confirmed the importance of human capital, capital investment, R&D spending and of the proximity effect, although again, the relationships were weak. The effects of other commonly-cited determinants of productivity also remained unproven.[5]

For the UK, 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. 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 to other 'region specific' factors. They also demonstrate that these results are not dominated by the effects of London and

the South East, and that the effects of economic mass are greater in the case of less productive areas.

Other studies have shed light on the determinants of productivity by focusing at the level of the individual firm as opposed to territorial differences. BARNES AND HASKELL (2000) demonstrate the wide dispersion of productivity levels with the top decile of establishments between 3.5 and 6 times as productive as the bottom decile, depending on the sector. CRISCUOLO AND MARTIN (2003) use the Office of National Statistics' Annual Response Database to investigate the impact of foreign ownership on productivity. Using a Cobb-Douglas production function which includes capital and materials and where the dependent variable is real output they find strong evidence of a US productivity advantage which is consistently greater than other multinational enterprises (MNEs). However, they find that MNEs *per se* also have a productivity advantage over other non-MNEs. These conclusions are consistent with those of others; see for example, DOMS AND JENSEN (1998) and GRIFFITH *et al*. (2004).

REGIONAL PRODUCTIVITY DIFFERENTIALS

Regional productivity differentials in the UK are substantial. Aggregate-level data from the Office of National Statistics demonstrates that there are wide differentials in productivity between the regions and countries of the UK. Gross Value Added (GVA) per head varied from £12,629 in Wales to £20,990 in London in 2003. GVA per head in Wales stood at 79% of the national average in 2003 compared with 131% for London and 115% for the South East. Similar differentials are apparent using alternative measures of productivity such as GVA per employed person. GVA per head exaggerates productivity levels in London and, to a lesser extent, the South East and East relative to other regions because it includes the output generated by inwards commuters, but the relative position of the regions changes little when account is taken of this. These differences have, moreover, been persistent over time with very little change in the relative position of the different regions. The South East has improved its position to some extent relative to other regions over the last decade. Wales and the North West have fallen back slightly. The overall picture has, however, changed little over time. This is in line with much of a considerable literature on regional convergence which has in general found little evidence of this occurring certainly in the short to medium term (GARDINER et al, 2004).

This paper seeks to add to the evidence base on the determinants of inter-regional productivity differentials. It does so by attempting to explain such productivity differentials in terms of a comprehensive set of variables likely, on the basis of existing evidence, to have an impact on such differentials – for a comprehensive literature review on which this selection of variables was based see BODDY et al, (2005). The core analysis draws on the Office of National Statistics data-base of establishment level information, described below. 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. Having first established the dimensions of regional productivity differentials, we set out the basic model for the analysis of productivity differentials. We then describe the data on which the study draws and discuss issues including our treatment of multi-region firms and of regional price differences. This is

followed by the empirical results of the analysis. Finally we draw out conclusions and implications.

THE DETERMINANTS OF REGIONAL PRODUCTIVITY DIFFERENTIALS: THE MODEL

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

$$Y = AK^{\beta 1} L^{\beta 2} \quad (1)$$

where K is capital stock, Y gross value added at factor cost (GVAFC) and L is labour force. 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.:

$$A = \exp(\beta_0 + \boldsymbol{\beta_3 X} + \text{Industry variables} + \text{Regional Variables}) \quad (2)$$

Taking logs gives us:

$$\ln(Y) = \beta_0 + \beta_1 \ln(K) + \beta_2 \ln(L) + \boldsymbol{\beta_3 X} + \text{Industry Variables} + \text{Regional Variables} + u \quad (3)$$

where u is an error term which we assume is normally distributed and well-behaved. The regional variables show the extent to which output in a specific region differs from the 'control or benchmark region' in percentage terms (we define this as London as the region with the highest level of productivity based on aggregate ONS data) given the firm's industrial sector and the size of firms in the region. We are looking at total output, i.e. GVAFC, but the analysis is totally consistent with focusing on labour productivity or indeed capital productivity.

GARDINER et al (2004) distinguish between workforce factors and productivity differentials, as such, as determinants of the headline measure of output per head of population. Here we explicitly include employment as a variable. We thus relate output to employment and thus focus on output per employee as a measure of productivity rather than output per head of population. The focus is thus directly on differences in labour productivity rather than the potential influences of workforce size[6]. Gardiner et al among others have also suggested output per hour worked as the preferred measure, taking account of differences across spatial units in hours worked and measuring actual labour input more accurately. Data on labour input in terms of total hours worked is not available from the ONS establishment-level data-base. We are able, however to include the ratio of full-time to part-time workers at establishment level giving some measure of variation in hours worked, with the expectation that the greater the proportion that are employed part time, then the lower will be output. Like GARDINER et al (2004, 1049) we see competitiveness as an 'aggregative concept' and our focus is on labour productivity as a key component, along with the employment rate, of what they term 'revealed competiveness'. The aim is to unpack and start to make sense of labour productivity as a source of competitive advantage.

The key factor is what to include in **X**, i.e. the set of independent variables other than labour, capital, industry and regional variables. To an extent this is dictated by the literature that has been reviewed above. We have seen that it has been suggested that multinationals are more efficient than non-multinationals and US multinationals are generally found to be more efficient than other multinational firms. Locational variables have also been found to be significant in determining productivity. Hence we will also include population density and distance factors, but unlike most other analyses we include travel time as well as distance in miles. This is an important distinction. The former can be affected by economic policy whereas the latter cannot. Skill variables are also found to be significant in many analyses. Here we include skill levels in the local authority area in which the individual establishment is located as a measure of skill levels in the local labour market. Again, this is a level at which policy measures might be expected to have some potential leverage on skill levels that might, in turn, impact on productivity.

Other 'key drivers' identified by the Treasury on the basis of existing evidence include investment, innovation, enterprise and competition. Drawing on the establishment-level data-base we are able to include capital stock rather than investment as such. We include R&D expenditure and also web access for outside users as indicators of innovation and willingness to adopt techniques that might impact positively on levels of productivity. We were not able to include direct measures of competition as such, although the presence of multinationals and proximity to major centres of economic activity as modeled by time and distance variables and population density are likely to capture this to some extent. We also include a variable for the number of establishments which make up the firm on the basis that there may be additional transactions costs involved in organising multi-establishment firms, with a negative impact on productivity.

DATA: SOURCES AND ISSUES

The analysis presented here is based on establishment level data held by the Office of National Statistics in the Annual Respondents Database (ARD). This brings together a wide range of data relating to individual business units and is described more fully in ONS (2002). The major advantage of this data source is that it allows the relationship between a range of variables to be examined at the level of individual establishments. It also allows various measures of productivity to be analysed at the level of these individual business units. Prior to 1997 the database only covered the production sector but it has since been expanded to include all sectors. Information is drawn together from a variety of sources including historical records, tax returns and various surveys. It is biased towards larger establishments in that those with employment below a certain level are sampled on a random basis and hence are not surveyed every year. Analysts need to be aware of this bias when using the database to construct representative statistical data, but in general it will not affect the validity of the regression results.

It includes information on the number and location of individual establishments of multi-location firms. The actual data is, however, collected at a firm or enterprise level and then imputed in order to provide data for individual establishments. This presents a particular problem in terms of defining regional productivity for a multi-establishment, multi-regional firm, which is something we return to later. The database includes information on whether establishments are part of multinational businesses or not and, if

multinational, their ownership (US, other non-British multinationals and, by default British). Data on capital stock (at 1995 prices) has recently been estimated from investment data and is also available – the ARD database as a whole contains a wealth of information, only some of which we draw on here. The full set of variables included in the analysis is listed in annex 1.

It is also possible to link other data to the establishment dataset using postcode data available for all establishments. We use postcode information to link establishments to skill levels in the local authority area in which they are located – with skills data being drawn from the Labour Force Survey via NOMIS. This provides an indication of the level of skills in the local labour market on which the individual establishments draw. There are several advantages to using skills designed in this way compared to using firm specific skills data. Firstly, this skills variable is more amenable to policy intervention than firm specific skills. Secondly, firm specific skills suffer from obvious endogeneity problems in that highly productive firms may hire the most skilled workers We similarly linked establishments to population density in their local authority area. We also added in data on distance and travel time from individual establishments (based on the postcode of their local council office) to both London (defined as the Bank of England) and to other major concentrations of population, employment and economic activity (Leeds, Birmingham, Glasgow and Manchester).[7] For this we used *Route-map* on the AA website[8] which provided both distance (by road) and travel-time data (by road). Travel time relates to the year when we accessed the distance data, that being 2005, and we must make the assumption that relative travel times have not changed significantly in the last 3 years. For multi-establishment firms, all these figures represent the unweighted averages of all the establishments.

We faced particular problems with multi-establishment and particularly multi-region businesses. In order to address the issue of multi-region businesses, the regional dummy variables used to identify territorial differences were only included when the whole of a business was located in one specific region. The regional dummies therefore pick up differences that relate unambiguously to businesses wholly within that region. Multi-establishment, multi-region firms were coded as such – and are separately identified in the tables of results presented later.

A further problem relates to the use of price deflators. GVAFC may in part reflct not genuine productivity differences, but differences in prices, where the price for identical outputs is different in different regions. Deflators were derived from estimates of regional price levels produced by the Office of National Statistics (WINGFIELD, 2001) using estimates of price differences for services for the year 2000.[9] This was then used to deflate all firms in all regions. It is unsatisfactory in the sense that, firstly, it assumes that in a given region all firms in all industries are subject to the same regional deflator and, secondly, it assumes a common deflator within regions without differentiating between urban and rural areas. These are issues we return to later.

EMPIRICAL FINDINGS

Findings of the analysis are reported in Table 1. The model is estimated using OLS regression with standard errors corrected for heteroscedasticity using White's methodology. Dummy variables are included for industries and regions. Additional variables are added in to the model in successive columns. The dependent variable in

columns one to six is the log of GVAFC. In column six, GVAFC has been deflated using regional consumer price indices. The figures in column one reveal that when we simply take account of the size of the labour force employed by firms there are significant regional differences in productivity. Relative to establishments in London, the benchmark region, those in Wales are 37% less productive, those in the South West 29% less productive and for those in the South East the gap is 14%[10].

The findings reported in Table 1 show the effect on regional differentials of adding in a succession of additional variables. To summarise, the regional differences narrow slightly when we include capital stock (see column two). The gap between London and Wales falls from 37% to 32%, for the South West it falls from 29% to 23% and for the South East from 14% to 11%. In the third column we begin to take account of industry mix and the influence of different sectors. Statistically, these are all significant. Their overall impact on productivity levels in different regions varies considerably however. The fourth column adds in a range of additional establishment and locality characteristics including hours worked (ratio of full-time to part-time workers); skills (the proportion of the working age population with high and medium level qualifications); population density; travel time to London; ownership characteristics; and the number of establishments per business. Column five then adds in distance in miles to London, travel time and distance to the nearest of the next four largest conurbations, with neither being statistically significant; and finally the proportion of establishments that do not provide external access to a website (which does have a significant negative effect on productivity).

Table 1: Determinants of productivity, 2002

Taken together, the set of variables listed in column five effectively explains regional productivity differentials relative to London. Statistically speaking, having added in these variables, there is no significant difference in productivity levels between the individual countries and regions of Britain relative to London. In terms of individual variables, capital stock per worker, as we have already seen, has a considerable impact on levels of productivity overall. The ratio of full to part-time workers is, understandably, a significant factor (see column five). This does not necessarily mean that part-time workers are less efficient per se. This ratio represents a measure of total hours of labour rather than any implied difference in the productivity of full-time versus part-time workers per hour worked. Skills, represented by the level of qualifications in the local labour market, are also significant. The proportion of the local labour force with high or medium level qualification both have a positive effect on productivity, although only high level qualifications (NVQ4 and above) are statistically significant at the 1% level (see column five).[11]

Ownership structure, more specifically multinational ownership, clearly matters a lot. Findings suggest that establishments that are part of multinational businesses in general are more productive than UK non-multinationals. They also suggest that there is a hierarchy among multinationals. US-owned multinationals are the most productive, UK-owned multinationals the least productive with other (non-US, non-UK, who form the benchmark) multinationals somewhere between the two. Thus US multinationals are 7.9% more productive than the benchmark, UK multinationals 4.3% less productive than

the benchmark and UK non-multinationals 15.6% less productive than the benchmark – taking into account the effects of all the other factors included in the model. Thus the productivity gap between US multinationals and British non-multinationals is approximately 28%, i.e. the former are some 28% more productive than the latter.[12] One does, however, need to qualify this with the observation that only a part of non-UK multinationals are based in Britain and for foreign multinationals, their headquarters and administrative functions will typically be based elsewhere. To the extent that the latter are 'less productive' than those parts based in Britain then they may be more productive than businesses with their administrative headquarters in Britain. If however we assume that UK multinationals are at least as productive as other non-US multinationals operating in Britain (ie discounting the possible impact on UK multinationals of less productive headquarters and administrative functions) there is still a considerable gap in productivity relative to US multinationals. This would seem, therefore, to relate to something real in terms of US business practices, innovation or technology – over and above simply levels of capital per worker and locational factors which have already been taken into account in the model.

In terms of other variables, private establishments are shown to be significantly more productive than other establishments. Establishments in multi-establishment businesses, however, are no less productive than others, discounting the argument that greater internal transaction costs are a significant burden (or suggesting that they are outweighed by other factors). Establishments located in areas of higher population density are, however, more productive than others, taking into account the effect of all the other variables included in the model - although this finding is only marginally significant statistically speaking. This provides some support for arguments based in new economic geography that clustering or agglomeration may have some effects on productivity. Access to larger markets can bring scale economies. Larger urban centres provide access to large pools of labour and human capital with a variety of skills. They provide access to a wide range of subcontractors, suppliers and specialised services. They also increase the possibilities of collaboration and interaction with other businesses and participation in networks and other forms of contacts, promoting both learning and innovation.

Travel time to London also has a considerable effect on productivity – the longer the travel time to London the greater, on average, the productivity penalty on individual establishments. As noted above however, none of the other travel time or distance variables have a statistically significant effect. In addition when the journey times to the four major cities were included separately they were again insignificant. Distance to these centres is, however, significant with capital stock as the dependent variable (Webber and Hudson 2005), indicating that these variables do have explanatory power and hence validity in a different context. Time distance from London may also be picking up agglomeration effects rather than simply penalties in terms of travel time as such. Proximity to London is likely to generate significant agglomeration effects over and above those already accounted for by population density. It may also represent the speed of knowledge diffusion where best practice spreads from the centre (London) to other areas at a speed inversely proportional to peripherality. These findings overall replicate in general terms the emphasis on the importance of distance and peripherality suggested by RICE AND VENABLES (2004). This is an important addition to, for example, the Treasury's set of 'key productivity drivers'.

There are a number of possible explanations for the particular dominance of London and lack of significance of other conurbations in the analysis presented here and this is the focus for ongoing work, including the expanding the number of urban centres included in the analysis. Superficially, this conclusion is also at odds with Rice and Venables who found economic mass to be an important determinant of the distribution of income per worker across NUTS 3 regions of Great Britain including, specifically, when the effect of London was removed from the equation. This may reflect the additional variables included in the analysis presented here including, importantly, capital stock per worker, ownership and population density. In particular we find elsewhere (WEBBER AND HUDSON, 2005) capital stock per worker to be significantly linked to these other major centres of population. Given that this will increase labour productivity, this helps explain the difference between our results and those of Rice and Venables.

We also include in this final model whether establishments operate a web-site for outside users. This factor is statistically significant and the coefficient suggests that those firms with web access have productivity levels some 7.1% above others. As noted earlier, web-access is used as a general indicator of likely propensity to innovate and to adopt efficient working practices. We also included in other regressions a variable representing R&D expenditure at establishment level. This, however, proved to be insignificant statistically. This does not mean that for individual firms, e.g. in the pharmaceutical or aerospace industries (or indeed at the level of the national economy as a whole) R&D is not important. It does, however, suggest that for most firms, particularly most small, and perhaps medium sized, firms, innovation as measured by R&D expenditure as such is not an important determinant of productivity. The importance of web access and the factors that this variable may be picking up suggests rather that what is important is the adoption of best practice techniques, the rapid adoption where feasible of successful product and process innovations as developed by others.

In terms of industrial structure, productivity levels vary considerably across the different sectors. Establishments in the catering sector are considerably less productive than in other sectors. Establishments in the financial services sector are considerably more productive. *Differences* in industry mix as such, however, have only a minor impact on overall regional productivity differentials (looking at the difference between columns two and three). This is in line with findings of other studies. Wales is something of an exception, findings indicate that here the productivity gap relative to London falls by 7.0% when industry mix is added into the equation and suggesting that Wales is significantly disadvantaged by its industrial structure.

In order to test the robustness of the overall model, we re-estimated the equations restricting the sample to single plant firms, hence excluding firms in multiple regions. The results were essentially unchanged. We also estimated the model structure for 2001 data. There are some differences in terms of detail in findings between the two years. This would be expected particularly given differences in the set of businesses sampled in different years as well as, for example, price changes or changes in demand impacting differently on different sectors over time. For this reason it is important not to read too much into the precise values of the coefficients as these vary between years. However, the overall structure of the model findings and the relative importance (and statistical significance) of the different coefficients is however, very similar between the two years.

This is also the case if we estimate across a panel of firms from 1998-2002. This in itself is provides confidence in the robustness of the findings overall.

We also explored the impact of applying regional price deflators to GVAFC, using the model represented by column six in table 1. This is on the basis that apparent productivity differentials across different territorial units may reflect differences in prices. The use of the deflator is unsatisfactory in he sense that it is applied to all firms in a region equally and does not distinguish between firms in different industries nor indeed between firms in urban and rural areas. Because of this the results need to be treated with caution. The results did not, in any case, add much to the findings reported above. The effects and significance levels of the main variables were very similar. Interestingly, the coefficients on all the regional dummy variables were now positive, suggesting that productivity differentials relative to London might be slightly lower than they might appear once the effect of price differences are taken into account. The positive differentials were, however small and, with only two exceptions, not statistically significant such that not much can be read into these findings. Interestingly as well, travel time to London remained significant and similar in size – in other words, the travel time variable was not erroneously picking up the impact of price differentials between the core and more peripheral regions.

CONCLUSIONS AND IMPLICATIONS

There are clearly marked differentials in productivity across UK regions. London has the highest level of productivity. The initial gap between London and the other regions ranges from 37% in the case of Wales, and 32% for the North East down to 14% in the case of the South East. These differentials can, however, be accounted for statistically by a combination of factors including differences in levels of capital per worker, hours worked (ratio of full to part-time staff), workforce qualifications, population density, industrial structure, ownership, travel time to London and the proportion of establishments offering web access (a proxy for adoption of innovative practices). With the inclusion of this set of variables, regional productivity differentials are reduced to a level that is statistically insignificant. Regional productivity differentials can be entirely accounted for, statistically, by a relatively small number of factors with a very plausible relationship to productivity.

The analysis brings together in a single explanatory model a range of explanatory variables and indicates their contribution to regional productivity differentials in Britain. The analysis therefore goes beyond those studies that have related productivity to a range of possible indicators but which have stopped short of econometric analysis as such. It also goes beyond those studies that have focused on the pair-wise relationship between productivity and individual ‘drivers’ of productivity such as skills or innovation. The latter would include the Treasury studies which identify ‘key drivers’ but do not attempt to address their overall impacts in any comprehensive fashion. The work presented here complements and extends that of GARDINER et al (2004) for the EU and RICE AND VENABLES (2004) for the UK. It draws together a more comprehensive set of explanatory variables including, importantly, capital stock. It also takes advantage of individual establishment data from the ONS ARD rather than data for spatial aggregates, the sample size afforded by this together with the range of variables and possibilities of linking other data sets to it.

Table 2: Summary of Key Findings

The impact of some of the key individual factors are summarized in Table 2. From a policy perspective, capital employed per worker clearly has an important impact on productivity levels. With some exceptions (notably Wales) it is not, however, apparently a huge determinant of regional differentials. Levels of capital employed however have only limited susceptibility to policy leverage. Levels of qualifications are clearly relevant in impacting upon productivity differentials. They are perhaps, however, less important than is frequently implied in the policy literature in particular, including the Treasury studies.

In terms of ownership structure, there are clearly significant benefits to be gained by expanding the representation of establishments that are part of multinational organizations, particularly US and other non-UK multinationals in the lagging regions. The potential supply of foreign direct investment is however, limited and competition is strong internationally for what is available. Of equal importance is to try to understand why there is this productivity differential related to multinationals and in particular US multinationals. It may then be possible to 'mimic' these effects through some form of policy intervention. One possibility is that multinationals are quicker to absorb new best practices. The importance of web access as a proxy for innovative behaviour also suggests the importance of measures to promote the adoption of best practice techniques, and the rapid adoption where feasible of successful product and process innovations developed by others.

Industrial mix as such does not seem to be a significant determinant of current regional productivity differentials. The scale of difference in productivity levels between particular sectors is, however, very considerable. This suggests that if the lagging regions could attract more businesses in financial services for example this might go some way to close the overall productivity gap. Similarly, regions such as the South West with a high concentration of establishments in tourism might benefit from reducing their dependency on the low productivity catering sector or by promoting investment in higher value-added components of the sector.

The importance of travel time from London suggests the overall impact of peripherality on regional productivity differentials. In simple terms, it also emphasizes the potential impact of reducing journey times on such differentials. There are clear policy messages here in terms of investment in transport infrastructure and the potential impacts on productivity. Significantly it is journey time that emerges as important from this analysis rather than simply distance in terms of miles – important given that investment could possibly reduce journey times but not geographical distance. It also, however, suggests the productivity penalties faced by establishments locating some distance from the capital region. As noted earlier, this variable may also, however, be picking up agglomeration effects rather than simply penalties in terms of travel time as such. Again, however, reducing journey times could potentially spread the positive effects of agglomeration focused on London.

Thus overall, the work emphasizes that a number of factors drawn from different theoretical perspectives are significant in determining productivity differentials. This was always likely to be the case, but in doing so we can conclude that 'geography matters' and analyses that exclude geographical variables such as location and population density

– and this includes many, even most, of the econometric studies on micro data – miss out an important factor with the consequent risk of substantial bias. Clearly much work still needs to be done. The results relating to distance need to be both explored in more depth and, if verified by subsequent research, understood. What makes distance from London so critical in terms of determining productivity and is this also the case for other countries with respect to their major/capital cities? The impact of skills and qualifications also needs more analysis. Further work will also become possible as further data becomes available relating to, for example, the age of the firm or the proportion of its output which is exported. Finally, a crucial area for future research is the construction and impact of price deflators, both inter-regional but also intra-regional differentiating between urban and rural areas.

Table 1: Determinants of productivity, 2002

	1	2	3	4	5	6
Log(employment)	1.027 (391.68)	0.716 (167.2)	0.697 (160.41)	0.704 (147.48)	0.702 (146.63)	0.704 (146.96)
Log (capital)		0.267 (85.77)	0.294 (85.70)	0.248 (64.96)	0.246 (64.00)	0.249 (64.72)
Full time ratio				0.706 (40.51)	0.700 (40.07)	0.706 (40.18)
Log (high skills)				0.122 (7.25)	0.126(7.16)	0.114 (6.75)
Log (med. skills)				0.145 (2.41)*	0.143 (2.36)*	0.117 (1.94)*
Log (pop den)				0.009 (2.25)*	0.013 (2.66)	0.008 (2.05)*
Log(London time)				-0.060 (5.75)	-0.074 (3.18)	-0.052 (4.44)
Log(London miles)					0.016 (0.82)*	
Log (city time)					0.017 (0.57)*	
Log (city miles)					-0.005 (0.14)*	
Log (distance)					-0.009 (1.01)*	
UK multinational				-0.043 (2.51)	-0.044 (2.62)	-0.040 (2.35)*
US multinational				0.075 (2.78)	0.076 (2.79)	0.075 (2.74)
UK non-multi-national				-0.171 (9.50)	-0.170 (9.47)	-0.168 (9.32)
Private firm				0.169 (7.74)	0.175 (7.99)	0.165 (7.56)
Log (#plants)				-0.014 (2.35)*	-0.013 (2.19)*	-0.016 (2.65)
Noweb					-0.069 (7.33)	
Regional Variables						
NW	-0.328 (15.08)	-0.258 (12.99)	-0.231 (12.14)	0.007 (0.27)*	0.015 (0.48)*	0.080 (2.64)
YORKS	-0.328 (14.75)	-0.278 (13.79)	-0.251 (13.11)	-0.016 (0.62)*	-0.003 (0.09)*	0.071 (2.32)*
NE	-0.381 (12.16)	-0.338 (11.88)	-0.283 (10.62)	0.003 (0.09)*	-0.011 (0.31)*	0.103 (2.78)
WMIDS	-0.297 (13.47)	-0.258 (12.68)	-0.244 (12.48)	-0.024 (1.00)*	-0.009 (0.32)*	0.043 (1.53)*
WALES	-0.460 (21.48)	-0.381 (19.78)	-0.283 (15.57)	-0.039 (1.53)*	-0.045 (1.65)*	0.062 (2.04)*
SCOTLAND	-0.278 (14.03)	-0.234 (12.74)	-0.189 (10.75)	0.121 (2.07)*	0.115 (1.96)*	0.173 (2.77)
SW	-0.342 (15.80)	-0.265 (13.38)	-0.213 (11.18)	-0.008 (0.32)*	-0.025 (0.91)*	0.052 (1.75)*
EMIDS	-0.310 (13.66)	-0.265 (13.38)	-0.240 (12.30)	-0.019 (0.77)*	-0.019 (0.70)*	0.044 (1.54)*
EAST	-0.287 (9.99)	-0.227 (8.50)	-0.205 (7.96)	-0.004 (0.13)*	-0.014 (0.46)*	0.027 (0.83)*
SE	-0.154 (7.91)	-0.120 (6.68)	-0.103 (5.99)	0.016 (0.73)*	0.005 (0.23)*	0.044 (1.85)*
BEDS	-0.149 (5.59)	-0.116 (4.75)	-0.125 (5.37)	0.011 (0.42)*	0.005 (0.18)*	0.041 (1.43)*
Multi-Region	-0.043 (2.22)*	-0.042 (2.45)*	-0.099 (6.01)	0.060 (2.68)	0.055 (2.22)*	0.113 (4.40)
Industry Variables						
Power			0.457 (4.25)	0.247 (2.04)	0.243 (2.01)*	0.253 (2.09)
Construction			0.657 (36.17)	0.420 (20.98)	0.424 (21.15)	0.420 (20.83)
Wholesale			0.445 (33.08)	0.314 (21.79)	0.311 (21.52)	0.315 (21.73)
Catering			-0.387 (22.02)	-0.290 (15.12)	-0.291 (15.17)	-0.291 (15.08)
Transport			0.316 (16.83)	0.138 (6.78)	0.139 (6.62)	0.139 (6.85)
Financial			0.871 (26.94)	0.645 (19.32)	0.636 (18.93)	0.644 (19.29)
Realestate			0.550 (37.84)	0.378 (24.52)	0.374 (24.20)	0.377 (1.49)*
Mining			0.176 (3.67)	-0.071 (1.40)*	-0.066 (1.29)*	-0.076 (1.49)*
Manufacturing			0.288 (20.14)	0.051 (0.17)*	0.051 (3.18)	0.054 (3.36)
Observations	41477	40490	40490	31236	31198	30962
R^2	0.85	0.88	0.89	0.91	0.91	0.91

Equations estimated by OLS, with standard errors corrected for heteroskedasticity using White's methodology. (.) denotes *t* statistics and a * denotes the variable is *not significant* at the 1% level. The dependent variable in each regression is Ln GVAFC except for column 6, where it is deflated by the regional productivity deflator. All coefficients are expressed as Ln. Constant terms omitted.

Table 2: Summary of Key Findings

Initial productivity gap relative to London[1]	
North West	-28.0%
Yorkshire	-28.0%
North East	-31.7%
West Midlands	-25.7%
Wales	-36.9%
Scotland	-24.3%
South West	-29.0%
East Midlands	-26.7%
East	-35.0%
Beds	-13.8%
Multi-region	-4.2%
Productivity differences by sector[2]	
Power	+27.5%
Construction	+52.8%
Wholesale	+36.5%
Catering	-25.0%
Financial	+14.9%
Real estate	+45.4%
Mining	-6.4%
Manufacturing	
Impact on GVAFC of:[3]	
a 10% increase in Employment	+7.0%
a 10% increase in Capital	+2.9%
a 10% increase in % with NVQ4+	+1.3%
a 10% increase in % with medium qualifications	+1.4%
a 100% increase in population density	+1.3%
web access to outside users	+7.1%
a reduction in travel time to London from 90 minutes to 30	+12%
a reduction in travel time to London from 180 minutes to 30	+22%
a business being in the private sector	+19.1%
Productivity compared with UK non-multinational[3]	
US multinational	+28%
Non-US, Non-UK multinational	+19%
UK multinational	+13%

1. Initial productivity gap relative to London with only total employment included – derived from column one of table 1.
2. Productivity compared to the default category of all other industries not listed – derived from column 5 of table 1.
3. Derived from column 5 of table 1. Differences expressed relative to UK non-multinationals (ie not the original benchmark of non-UK, non-US-multinational as in table 1)

Annex 1: definition of variables

Dependent Variable	Gross value added at factor cost, sometimes deflated by regional price deflator.
Employment	Number of workers the firm employs, full and part time (ie not full-time equivalent)
Capital,	The capital stock of the firm in constant prices obtained from the ARD database, estimated by the ONS.
Full time ratio,	The proportion of workers who are full time
High skills:	The proportion of the labour force 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, Annual Labour Force Survey, NOMIS.
Med skills:	The proportion of the labour force who have some, but not 'high' skills, Annual Labour Force Survey, NOMIS.
Pop Den	The population density in the local authority district, from NOMIS
London Time	The distance it takes to travel from the main council offices in the locality to the Bank of England by road as determined from the AA website
London Miles	The distance in miles from the main council offices in the lcality to the Bank of England by road as determined from the AA website
City Time	The distance it takes to travel from the main council offices in the locality to the council offices of the nearest of Birmingham, Manchester, Leeds or Glasgow by road as determined from the AA website
City Miles	The distance in miles from the main council offices in the locality to the council offices of the nearest of Birmingham, Manchester, Leeds or Glasgow by road as determined from the AA website
UK multinational	Takes a value of one if the firm is a UK multinational
US multinational	Takes a value of one if the firm is a US multinational
UK non-multinational	Takes a value of one if the firm is a British, non- multinational
Private Firm	A privately owned firm
# Plants	The number of plants which go to make up thee firm
Noweb	Takes a value of one if outside users cannot gain access to the firm's website.
Regional Variables	Takes a value of 1 if the firm is wholly based in the Great Britain region: North West (NW), Yorkshire and Humberside (YORKS) , North East (NE) , West Midlands (WMIDS), Wales (WALES) , Scotland (SCOTLAND) , South West (SW), East Midlands (EMIDS), East (EAST), South East (SE), Bedfordshire (BEDS) – now part of SE but identified separately in ARD.
Multi-Region	Takes a value of one if the firm has multiple plants in different regions.
Industry Variables	Take a value of 1 if the firm is in the following sectors
Mining	defined as sic92<15000
Power	defined as sic92>15000 & sic92<40000
Construction	defined as sic92>45000 & sic92<50000
Wholesale	defined as sic92>50000 & sic92<55000
Catering	defined as sic92>55000 & sic92<60000 and includes hotels
Transport	defined as sic92>60000 & sic92<65000
Financial	defined as sic92>65000 & sic92<70000
Realestate	defined as sic92>70000 & sic92<75000
Manufacturing	defined as sic92>15000 & sic92<40000

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NOTES

[1] Public Service Agreement targets set in 2004 include as a joint commitment for HM Treasury, the Office of 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)

[2] We focus here specifically at the scale of the regions and countries of the UK. There has also been increasing debate over the role of local areas, cities and city-regions in contributing to productivity, competitiveness and economic growth (HM Treasury, 2001, 2003; other refs) and we are exploring this dimension in ongoing work focused on the English 'core cities' (Boddy and Webber, 2005).

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

[4] This was similar to the UK Productivity and Competitiveness Indicators 2003 produced by DTI in order to provide for international comparison of UK performance across a wide set of factors (DTI, 2003)

[5] As reported in Gardiner et al (2004) the study also demonstrated that productivity growth is a key determinant of economic prosperity across the EU regions (rather than workforce factors) and that convergence in levels of productivity across regions has been very slow and, since the latter part of the 1980s, absent.

[6] Although economies of scale will be present if $\beta_1+\beta_2>1$.

[7] This is a rather limited measure of proximity to mass in terms of population, employment or economic activity. But nonetheless, should still give an indication of the relative importance of nearness to major urban conurbations from which we can extrapolate to the impact of proximity in general. In general measures which give a weighted distance to all urban centres are based on mileage and not travel time.

[8] www.theAA.com

[9] ONS regional price estimates are produced for specific years only, not as an annual series. 2000 data are the best fit to the available establishment level data used in the analysis which spans the period 1998-2002. Regional price indices have been further developed and refined in later work by ONS (Wingfield et al, 2005). Price differences for services were used on the basis that they are more clearly linked to differences in regional costs than the price of goods which may have a relatively large import content.

[10] These figures are found by taking the exponential of the regression coefficient. For Wales this is 0.631, implying Welsh firms are only as 63% as productive as London ones. That is given the same workforce a firm in Wales will tend to produce 37% less than one in London. Labour productivity will depend upon the number of workers, but for firms with a workforce of a given size and holding all other characteristics constant, this figure also represents the difference in labour productivity.

[11] Other versions of the analysis using medium level skills as the benchmark demonstrate specifically that the proportion of the workforce lacking basic skills does have a negative impact on productivity and is statistically significant. Indeed there is some evidence that this is the key problem in terms of productivity, i.e. areas with relatively high concentrations of workers with no formal qualifications at all.

[12] The gap expressed relative to UK non-multinationals ie (107.9-84.4)/84.4*100