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Productivity in Wales: the impacts of peripherality on spatial patterns of productivity

Final Report to the Economic Research Advisory Panel

Welsh Assembly Government

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PRODUCTIVITY IN WALES: THE IMPACTS OF PERIPHERALITY ON SPATIAL PATTERNS OF PRODUCTIVITY

EXECUTIVE SUMMARY

The study

1. It is well established that there is a significant gap between productivity in Wales compared with the UK average. There are also major differences in productivity across Wales. Previous work for the Welsh Assembly Government identified remoteness or peripherality as a key determinant of differences in productivity and competitiveness once factors such as capital stock, industrial structure, skills and other factors had been taken into account. This report presents findings from a further study commissioned by the Welsh Assembly Government from the University of West of England, Bristol, designed to investigate in more detail the nature peripherality and its impact on spatial differences in productivity.[1]
2. The aims of the study were:
   - To examine in detail, spatial variation in productivity across Wales and the determinants of this variation in order to establish the possible impacts of peripherality on productivity and economic performance.
   - To develop a range of different indices of peripherality in order to explore the impacts of peripherality.
   - To provide outputs in the form of maps of peripherality across Wales based on different indices.
   - To derive from the analysis spatial patterns of residuals from the econometric model – identifying parts of areas where levels of productivity diverge in particular from those predicted by the model.
   - To discuss the possible implications of spatial patterns of productivity and the impacts of peripherality in particular, policy implications.[2]

Peripherality

3. Peripherality matters because it captures a broad range of potential effects. One early study stressed that peripherality represents:

   > … a broad surrogate indicator of possible markets for traded goods and services, of input sources and opportunities for component linkages, of the availability of commercial information and business services … distance costs of all kinds … rather than narrowly or simply … transport costs of the type implied by traditional Weberian industrial location theory… (Keeble et al, 1988, 12).

4. Peripherality potentially impacts on access to markets, suppliers, people and skills, and information. It also however impacts on access to agglomeration economies

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[2] This work contains statistical data from ONS which is Crown copyright and reproduced with the permission of the controller of HMSO and Queen's Printer for Scotland. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

(returns to scale, specialist suppliers and services, larger pools of skills, supportive institutions and networks. And it impacts on access to knowledge spillovers, innovative milieu and non-market forms of collaboration fostered by face to face contact.

5. The study constructed indices of accessibility based on travel time by road to local towns and cities, and of peripherality based on distance, via the road network from any one local authority area to all others in England and Wales, weighted by the mass or size of each place measured in terms of population. It also combined the two in different ways.
6. These proved more effective in terms of explaining productivity differentials than the somewhat crude measures employed in earlier studies. In practice, the 'index of accessibility' based on travel time to towns and cities proved to be somewhat better at explaining such differences than the alternatives – suggesting that it is more localised differences that matter rather than economic potential at a much broader geographical scale.
7. This would also suggest that with the exception of Cardiff and the eastern end of the M4 corridor, Wales as a whole is peripheral compared with England such that the more broadly defined index of peripherality is less effective at picking up differences between places, particularly those further away from the economic centre of gravity of England and Wales.
8. Figure one shows the pattern of local accessibility across England and Wales, one of a range of measures generated by the study. This can be compared with Figure two which shows the pattern of productivity differentials which, is readily apparent, shows a considerable degree of similarity with the map of local accessibility. The analysis set out to determine the importance of peripherality and accessibility once other relevant factors such as industry mix and numbers of workers had been taken into account.
9. The statistical analysis, reported in detail in the main report, clearly demonstrates the importance of accessibility and peripherality as having a significant impact on productivity, once other factors have been taken into account. This is the case in terms of spatial differences in productivity across Wales and England as a whole. It is also the case at a more detailed level within Wales.
10. Analysis of productivity differentials within Wales points to the sharp differences between South East Wales (and the M4 Corridor in particular) on the one hand, and the West Wales in particular. The same is true comparing North East Wales and adjacent areas of England with Central and North West Wales. These would seem to reflect to a significant extent the sharp differences in accessibility between these sub-regions evident from the detailed mapping of this index.

Figure 1: Standardised local accessibility

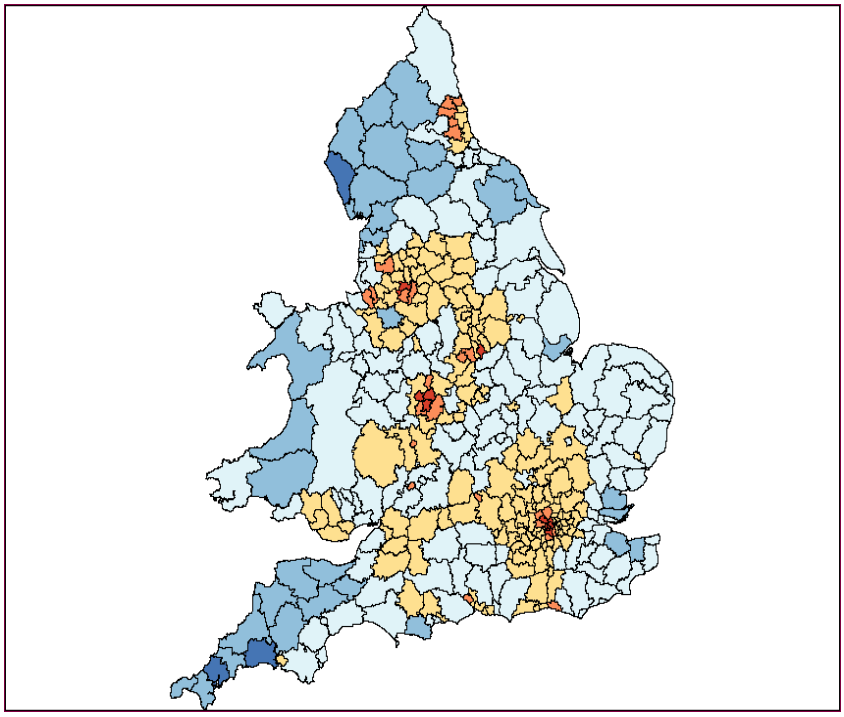
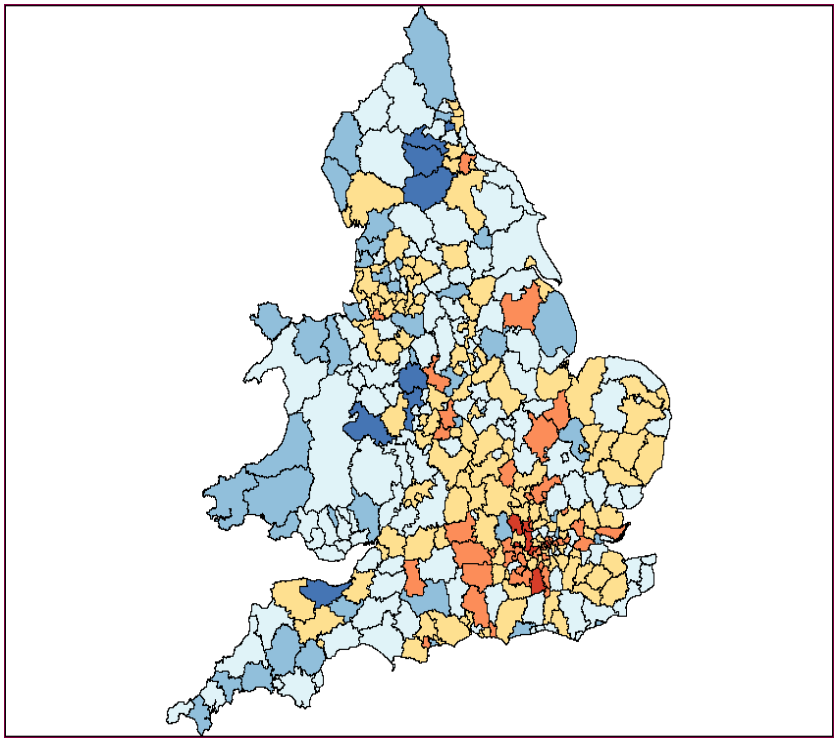


Figure 2: Labour productivity



Policy implications

11. The analysis raises a wide range of possible issues from a policy perspective with a view to offsetting at least to some extent the impacts of peripherality.

Improving transport infrastructure

12. The benefit to more peripheral regions of physical transport infrastructure investment, such as improved rail or road links is at one level an obvious response to issues of accessibility and peripherality. The benefits are not always, however, as self-evident as they may seem. Investment frequently improves links to and reinforces the relative advantage of existing urban areas.

13. In the case of Wales, for example, the benefits of the old and second Severn crossings in terms of the development of the Welsh M4 Corridor up to and including Cardiff would seem to be clear. We do not have specific evidence but the benefits of extending the M4 further west may have to a significant extent accrued to Cardiff and south east Wales as well as to places further to the west. There are however, few examples of successful economic development in places that lack good transport infrastructure and whilst it may not be a sufficient condition for economic competitiveness, it can be argued that it is necessary.

Sector differentiation

14. Different types of economic activity will be impacted on by poor accessibility and peripherality in different ways. It may be possible to identify sectors or sub-sectors, or types of activity differentiated in some alternative way, at to promote and support the development of these in more remote areas.

15. Accessibility, proximity to larger agglomerations of economic activity and locations with high levels of economic potential confer considerable benefits in terms of competitiveness and productivity. Turning this on its head, support for and promotion of types of economic activities where the factors underlying these benefits are less relevant may present opportunities. One would be seeking to identify activities where, for example, physical access to concentrations of high market demand, proximity to specialist suppliers and business services and localised interaction with other businesses were largely irrelevant.

Focus on more peripheral areas with the greatest potential

16. It also needs to be recognised that rural areas with possible comparable levels of peripherality as measured by indices, vary greatly in terms of their attractiveness to more highly skilled and qualified ‘knowledge workers’ and entrepreneurs – this can be seen from the distribution across rural areas of the proportion of the working-age population qualified to degree level or above. This suggests the possible benefits of targeting investment and policy intervention on areas with a high concentration of such populations.

Aggregation of supply chains or market potential

17. Many suppliers in more remote areas are relatively small and relatively isolated one from another. Any one supplier of goods or services is unlikely to be able to make a significant impact in terms of establishing contacts, marketing or ensuring significant supply volumes to volume markets in more distant markets.

18. There are examples, however, of rural, quality food producers, which have been able to combine forces and to successfully market under a joint brand name a range and volume of goods that can be supplied to major retailers and supermarket chains

Capitalising on intrinsic value

19. It may also be possible to promote and support activities which derive value and market potential specifically from the (more remote) locations and the attributes of these products or services that derive intrinsic value from their location that can offset what are otherwise the disadvantages of poor accessibility and peripherality. The branding and supply of local products in the food and drink sector is a well-tried example. Local accommodation and visitor attraction is another obvious and well-tried example

Promoting virtual accessibility and agglomeration

20. Physical remoteness and geographical dispersal have typically been seen as the key elements of poor accessibility and peripherality. It may, however, be possible to develop initiatives that counter this by electronic means. This would include the promotion of and support for e-marketing and e-sales and support, including services as well as physical goods.

21. Clustering in physical space has been much emphasised in recent studies emphasising the role of face to face contact and easy access in promoting trust, collaboration, knowledge exchange, and knowledge generation. It may be possible, however, to replicate some at least of this in a variety of forms through the promotion of clustering, 'business networking' (emulating the growth of social networking sites) and density of contacts in virtual or electronic space.

Exploiting economic mass

22. Cardiff is the one sub-region in Wales with above average levels of productivity in the overall context of England and Wales. Significantly it is the only part of Wales that enjoys levels of accessibility or 'centrality' comparable to the main urban areas of England and Wales. There are clearly issues of spatial equity but this provides a potentially strong argument for concentrating investment where it is likely to generate the highest returns in terms of productivity. Similar arguments might apply to Newport and Swansea which also benefit from the M4 corridor effect but represent smaller and in Swansea's case more remote clusters than Cardiff itself, and also to Flintshire and Wrexham in the North East.

National infrastructure projects

23. Levels of accessibility and productivity in Cardiff are comparable with those in other significant urban centres across England. The Second Severn Crossing in particular has clearly done much to improve accessibility and counter peripherality. By UK standards, however, it is nevertheless relatively limited in terms of economic mass certainly compared with London and the SE but also Birmingham and the midlands, or Manchester/Liverpool. This suggests that there are still benefits to be secured by addressing the barriers presented by the Severn Crossings and in particular the real and perceived effects of congestion and disruption on the M4 and M5. High speed rail links to London allowing business

to be conducted in the context of a day-trip are also likely to remain significant – providing considerable potential benefits compared with car-travel. In the north east as well the dense motorway network extending west from Manchester contrasts with provision over the border into Wales. North-South links within Wales are of course particularly poor. Any significant additional infrastructure investment would represent major projects to be addressed at a national level.

1. INTRODUCTION

1.1. It is well established that there is a significant gap between productivity in Wales compared with the UK average. There are also major differences in productivity across Wales, from Cardiff where labour productivity is well above the UK average to areas such as South West Wales and the Gwent Valleys where it is well below.

1.2. Previous work for the Welsh Assembly Government identified remoteness or peripherality as a key determinant of differences in productivity and competitiveness once factors such as capital stock, industrial structure, skills and other factors had been taken into account. This report presents findings from a further study commissioned by the Welsh Assembly Government from the University of West of England, Bristol, designed to investigate in more detail the nature peripherality and its impact on spatial differences in productivity.[3]

1.3. Previous work set out to establish:

- Key issues in relation to regional productivity differentials, their measurement and economic significance and implications
- The extent of productivity differentials between Wales and other regions of the UK and between different parts of Wales
- The key determinants of these productivity differentials including an indication of their relative importance
- The possible implications of these findings in terms of policy issues and different forms of intervention

1.4. The previous study identified a headline gap in productivity between Wales as a whole and London as the leading, bench-mark region in Great Britain of some 42%.[4] The study was able to explain, in statistical terms, much of the labour productivity gap between Wales and London based on a set of explanatory factors including differences in capital stock, industrial structure, ownership, qualifications, population density and an index of travel time to major centres of population and employment.

1.5. The importance of population density and travel time pointed to the importance of remoteness or peripherality as factors impacting on the productivity and competitiveness of businesses within Wales. Population density measured density in the district surrounding each individual business. The travel time index measured the average travel time from the district in which each plant was located to London and to the next four largest urban areas in Great Britain. The study found that the productivity of the average firm fell by 0.7% for every 10% increase in travel time. It also found that a doubling of population density was reflected in a 1.3% increase in productivity. Spatial factors, population density and travel time, were therefore clearly significant factors in explaining

[3] The study was carried out by Don Webber, Anthony Plumridge, Michael Horswell and Martin Boddy.
[4] Based on business-level data from the Office of National Statistics

the overall gap in productivity and competitiveness between Wales and more economically buoyant regions.

1.6. Using plant-level data from the Office of National Statistics the previous study was also able to analysis spatial differences productivity within Wales. Focusing on ten sub-regions it was able to identify differences relative to Cardiff as the leading, bench-mark sub-region (Table 1.1).

Table 1.1: Sub-regional productivity differentials in Wales relative to Cardiff, 2003	
Conwy and Denbighshire	33%
Swansea	30%
South West Wales	26%
Gwynedd and Anglesey	21%
Central Valleys	15%
Gwent Valleys	13%
Powys	8%
Monmouthshire and Newport	8%
Bridgend and Neath	7%
Cardiff (benchmark)	0%

1.7. Again, as with analysis at a regional scale, it was possible largely to explain differences in productivity at a sub-regional scale in terms of a set of plausible explanatory factors. Population density was included as one factor in the sub-regional analysis and, along with other variables contributed to the overall explanation of differences in productivity. It was not possible however, to include any meaningful index of peripherality as such in the sub-regional analysis. There remained, as well, significant anomalies – differences in productivity between sub-regions – which the analysis was unable to account for.

1.8. Other issues limited the extent to which the earlier study could identify issues relating to peripherality. First, the travel-time index used in the earlier study was relatively crude based as it was on travel time only to London and the next four largest conurbations in Great Britain – it represented in effect an exploratory element in the overall context of the original analysis albeit one which turned out in practice to point to important factors in explaining productivity differences. Second, within the limits of the data, the earlier study was able to provide some insights at a sub-regional scale. The sub-regions remained, however, relatively broadly defined and whilst population density was included, the index of travel time was too crude to be meaningful at a sub-regional scale.

1.9. Based on this earlier study however, and given the scale of differences in productivity and competitiveness across Wales as a whole and the apparent contribution to these differences of peripherality and remoteness, further

work was commissioned to look at this aspect of the analysis in more detail. The aims of the study, presented here, were:

- To examine in detail, spatial variation in productivity across Wales at a range of different geographical scales and the determinants of this variation in order to establish the possible impacts of peripherality on productivity and economic performance.
- To develop a range of different indices of peripherality based on travel time to centres of population and employment and the size of those settlements, applying different weights and functions in order to explore the impacts of peripherality in the context of other factors affecting productivity levels.
- To develop indices of peripherality in the form of a GIS data-base allowing them to be linked to individual plants in the ONS business-level database across Wales.
- To provide outputs in the form of maps of peripherality across Wales based on different indices.
- To apply these indices in the context of econometric analysis of the determinants of productivity, based on the most recently available ONS business-level data.
- To derive from the analysis spatial patterns of residuals from the econometric model – identifying parts of areas where levels of productivity diverge in particular from those predicted by the model.
- To discuss the possible implications of spatial patterns of productivity and the impacts of peripherality in particular, including policy implications.

1.10. The study was largely able to meet in full the objectives as set out here. The original brief was to focus on Wales itself and initial work on indices of peripherality focused on this study area. Following discussion, however, it was agreed to extend the scope of the study to cover England and Wales as a whole. The level of detail relating to Wales remained as it would have been. The extended study area provided, however, a much broader context within which to look at peripherality, differences in productivity and the factors impacting on these differences across Wales. It also allowed for comparison between Wales and other more geographical peripheral parts of England.

1.11. The original aims of the study included examining variation in productivity at different spatial scales. At project inception it was not possible to determine the spatial scales at which it would be possible to conduct the analysis and disclose results – this being dependent on ONS requirements regarding confidentiality of the original plant-level data, with release of results being dependent on ONS authorisation. In practice it proved possible to carry out the analysis and present results in map-form at the level of unitary authorities across England and Wales, merging small authorities in very few cases to meet ONS requirements. This was considerably more detailed than was possible in the previous study looking at sub-regions. Given the level of detail that this provided it was not considered necessary to focus on different spatial scales.

1.12. These differences apart, the study covered the sequence of aims outlined above. Section two, which follows, considers the nature of peripherality and accessibility and its possible impacts on productivity and economic competitiveness. Section three then describes the derivation of a range of

indices of peripherality. Section four presents the main statistical analysis carried out to establish the impact of peripherality on productivity differentials, in the context of other relevant variables. It concludes with an analysis of the spatial pattern of the 'residuals' or 'unexplained variation' which cannot be accounted for by the statistical models. Section five presents a further dimension to the analysis in the form of a 'spatial regression model'. This builds into the model itself the spatial structure which is evident in both the data on productivity and in the explanatory variables. This provides what is statistically a more robust model which fully captures the spatial relationships within the data. Section six presents a short exploration of the possible impact of aspatial or 'virtual' peripherality reflecting poor connectivity to ICT, business networks or sources of social capital. The final section then draws out key findings and explores policy implications.[5]

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2. PERIPHERALITY AND PRODUCTIVITY

2.1. Before setting out to develop statistical measures of peripherality, it is useful to unpack the concept and to consider its possible impacts and implications in terms of economic performance. Peripherality[6] can be conceptualised and defined at various spatial levels and it is important to consider the set of other places to which any given place might be considered to be 'peripheral'. Thus there is work at an international scale that focuses, for example on the peripherality of a nation such as New Zealand (McCann 2003) where the 'other' areas are global. Other work is focused at a supra-national level, as with the European Peripherality Index (Schurmann and Talaat (2002)) described earlier in section two. Here the spatial units are defined as NUTS3 areas of the EU and candidate countries and the 'other' areas against which the peripherality of any given spatial unit are defined are all other NUTS 3 areas within the study area. The present study aimed to look at spatial differences in productivity and competitiveness at a relatively fine-grained level – the aim therefore was to incorporate measured of peripherality appropriate to this level of resolution – as described in section 3, below.

2.2. One early study stressed that peripherality represents:

> … a broad surrogate indicator of possible markets for traded goods and services, of input sources and opportunities for component linkages, of the availability of commercial information and business services … distance costs of all kinds … rather than narrowly or simply … transport costs of the type implied by traditional Weberian industrial location theory… (Keeble et al, 1988, 12).

It is important to understand these differences and complexities in order to start to think about policy implications or broader strategic issues. The impacts and implications of peripherality are thus multi-dimensional and we can start to unpack these in the following way.

Access to markets or market potential

2.3. In terms of outputs, access to markets impacts on the costs and feasibility of getting goods and services to customers. Access does not simply impact through distance-costs but also includes for example the costs of communication, information gathering, levels of stockholding required, risk and uncertainty. It can also impact on the scope of market intelligence and other information flows, as well as non-financial factors such as trust and collaboration which can enhance competitiveness and which are enhanced by the possibilities for and frequency of face to face contact.

Access to suppliers of goods and services

2.4. Similar factors apply in terms of access to inputs including both goods and services. Again these include actual costs but also factors such as intelligence and information flows and non-market relationships such as trust and

[6] Peripherality is used in a general sense as defined by Goodhall, 1987, "the condition experienced by individuals, firms and regions at the edge of a communications system, where they away from the core or controlling centre of the economy" Elsewhere in this report, it is used specifically in association with an index and is defined accordingly.

collaboration which are enhanced by spatial proximity. These same factors apply specifically to supply chains where cost, information flows, certainty of supply and the need for (costs of) buffer stocks at different pointed in the supply chain are key considerations. Accessibility and peripherality clearly impact across these factors.

Goods, people, information and services

2.5. Accessibility and peripherality have different impacts and implications depending on whether one is talking about the flow of material goods of different sorts (weight, bulk, value perishability), of services of different types (which may involve flows of information in different formats or face-to-face contact) or specifically of individuals. It has been argued that as the nature of economic activity has shifted towards knowledge-driven, higher value, R&D dependent goods and towards more service-based activities, traditional transport costs as such have become less significant and contact between people have become increasingly important. Freight service quality, reliability and speed remain important to those activities where they are still relevant. The scale and scope of activities to which they are relevant is however now much reduced and direct transport costs represent a low proportion of total production costs across much of industry.

Agglomeration

2.6. Recent perspectives point to the importance of a range of factors which relate spatial differences in productivity and growth to increasing returns arising out of spatial agglomeration. The Treasury has argued that:

> …agglomerations, or clusters, of firms and skilled workers may be one of the key drivers of economic growth in localities, cities and regions. Successful clusters may be crucial to a region's success in attracting and retaining high productivity firms and workers. Agglomeration, whilst beneficial in itself, could therefore be a force for divergence as successful clusters attract increasing amounts of firms and workers. (HM Treasury, 2001, 34)

This may reflect increasing returns generated by localized knowledge spillovers, access to specialized suppliers and services, the scale of local markets and access to large and diverse pools of labour offering specialist skills. Larger scale agglomerations or access to 'economic mass' can simply represent larger scale markets for goods and services which can generate economies of scale for producers.

Clusters and innovation

2.7. According to some accounts, these are reinforced by locally-embedded institutional, socio-cultural and political structures and practices which tend to localize such external economies. These include relationships of trust and collaboration mentioned earlier, more easily developed and maintained in geographical concentrated, higher density networks. These can also take the form of a 'local innovative milieux' 'regional innovation systems'. There are parallels here, as well, with Porter's more eclectic 'cluster model' of regional competitiveness. Such approaches again see a virtuous circle with productivity growth and economic competitiveness locked in to some leading regions and localities and other areas locked out, with increasing regional

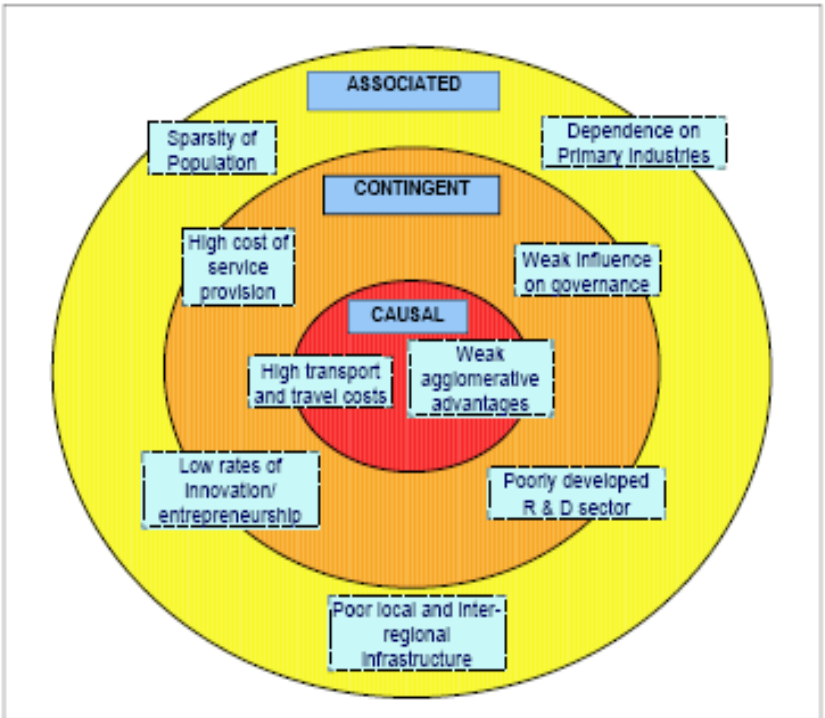
specialization and spatial concentration of economic activity a likely outcome. Accessibility or peripherality, from this perspective impact in terms of remoteness from and lack of access to in such increasing returns and the benefits of clustering.

2.8. More recent accounts have stressed the importance of the broader geography of the knowledge economy. This includes the role that concentrations of knowledge workers and knowledge-based activities can play in driving innovation and growth. It also includes the characteristics of different places and their attractiveness to such workers. American academic commentator Richard Florida (Florida, 2002) points to the key role of the 'creative classes' as the new drivers of competitive advantage. Similarly Kotkin and DeVol (2001) argue the importance of 'knowledge value cities'.

Aspatial peripherality

2.9. One of the main recent initiatives in the field was the EU AsPIRE[7] Framework 5 programme which funded a number of studies including some based on a survey of businesses in six peripheral and six less peripheral areas across the EU, as small as the District Council area level in the case of the Scotland case study (see Copus and Macleod (2004). This focused on what was termed 'Aspatial' aspects of peripherality. Initially, Copus and Macleod provide a conceptual model of peripherality as conventionally described:

Figure 2.1: The Elements of Conventional Concepts of Peripherality



Source: Copus and MacLeod, 2004

[7] Aspatial Peripherality, Innovation and the Rural Economy

They argue that the "causal" spatial factors appear to have less influence with the growth of the service sector and the growth of e-commerce and ICT. They propose a set of six aspatial dimensions of peripherality (Copus and MacLeod, 2004):

- ICT infrastructure
- Human capital (skills necessary to exploit ICT)
- Local Business Networks
- Social Capital
- Institutional Networks
- Local/Global Links

2.10. Associated with these dimensions, Copus and Macleod and others hypothesize the mechanisms by which they might be supposed to impact on economic performance. ICT (and the human capital to exploit it) are seen as compensating for deficiencies in physical communications infrastructure and providing a platform for e-business and e-commerce (Grimes, 2004). The position of Wales in relation to this "virtual peripherality" is discussed below. Business networks are seen as facilitating innovation while social capital allows the evolution of co-operation and trust. Institutional networks with sound governance support enterprises while global links allow the timely flow of new knowledge and information about opportunities to businesses in the area.

2.11. The Aspire programme attempted to assess the importance of these aspatial factors on business performance using a case study approach, surveying businesses and support agencies in 12 districts in 6 countries of the EU. The districts were chosen so that there was one peripheral and one less peripheral area in each country.

2.12. The findings with respect to ICT and human capital are considered in the discussion of virtual peripherality below. The role of social capital and institutional proved difficult to test empirically, although some evidence for the potential to compensate for peripherality was found. The findings in terms of the role of business networks and global links were more informative.

2.13. Dimara, Goudis and Skuras (2004), looked at business networks and global links as part of the AsPIRE programme. They distinguished between vertical links, from local area businesses to regional, national and global organizations and horizontal links between businesses in the local area. They postulated that strong links of both types were important for business success and found that there was a tendency for vertical links to be weaker in more peripheral areas. They also found that firm with strong local links tended to source inputs and market outputs locally, to the benefit of the local economy. Firms with strong vertical links tended to export output, helping to boost income flows into the area (Dimara, Goudis and Skuras, 2004).

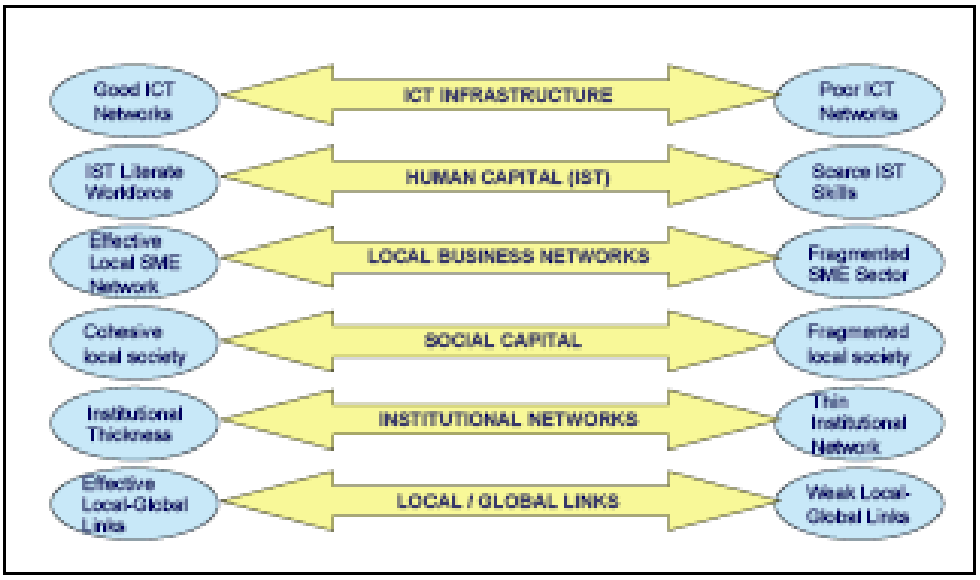
2.14. A related later paper by Copus, Skuras and Tsegenidi (2006) used the same data set to investigate innovation rates among firms in the 12 areas. They found that there was little relationship between firm growth and innovation but a significant tendency for innovation in more accessible areas to be greater.

This was not accounted for by firm level factors but by local area characteristics, including networks. (Copas, Skuras and Tsegenidi, 2006).

Virtual peripherality

2.15. The broad thrust of the results of our analysis above is that much of the variation in the labour productivity of businesses across the areas of Wales and the UK as a whole can be explained by firm level factors, sector, physical accessibility and spatial spillover effects. However, some unexplained variation remains and it possible that part of this could be due to the influence of what has been termed Aspatial Peripherality (Copus and MacLeod, 2004). Aspatial Peripherality (AsP) as described by Copus and Macleod can be grouped into three dimensions: poor utilisation of new information and communication technology, inadequate linkage to global business networks and weaknesses in governance structures and social capital. These are further subdivided into six elements in the figure 2.2 below:

Figure 2.2: Aspatial peripherality



Source: Copus and Macleod (2004)

2.16. The first two elements constitute what we term "virtual peripherality", a condition where relative access to and usage of communication and information technology CIT) is at low level. The contribution of all six elements to business growth in 12 study areas in the EU was the subject of the AsPIRE initiative, conclusions reported in a number of papers at the Regional Science Association conference in 2004. Evidence was found of some contribution of aspatial peripherality to explaining lower business growth in the more peripheral study areas.

2.17. There is some evidence of the influence of virtual peripherality on business performance from AsPIRE studies (Grimes 2004). There were two study areas in the UK, both in Scotland, Cumnock and Doon and Shetland. Neither area

had significant Broadband access, unlike other EU study areas. Nevertheless, there was a relatively high incidence of internet use by businesses for a wide range of commercial functions in both areas although there were a disproportionate number of businesses in primary sectors taking the view that fuller use of e-trading was inappropriate to their businesses. This was particularly marked in Shetland. A hypothesis that the survey sought to test was that virtual connectivity can compensate for spatial peripherality. The results suggested that this was generally the dominant view of respondent businesses, although not particularly markedly so in Scotland. In 2004 there was considerable inertia in adopting ICT as a fundamental trading platform. This was in part due to a lack of appropriate skills, an unwillingness to invest money and time in a business model not perceived as appropriate and the disincentive inherent in ICT infrastructure provision in peripheral areas.

2.18. Although there have been general improvements in the performance of ICT infrastructure since 2004, more recent work supports the general conclusions above, including a persistent relative disadvantage in ICT provision in rural areas (Defra 2005, Preston et al, 2007).

3. DEVELOPING INDICES OF PERIPHERALITY AND ACCESSIBILITY.

3.1. As noted above, previous work for the Welsh Assembly Government by the current authors had included only population density and a relatively crude measure of peripherality relative to major conurbations as possible explanatory factors. Here we review previous attempts to build peripherality into such analysis and describe the new measures developed for this study.

3.2. Rice and Venables (2004) looked at the impact on productivity of economic mass, measured as the size of the working-age population within a given drive-time of each NUTS 3 area across Great Britain. They find a significant effect of proximity to economic mass on productivity. This is greatest for mass within 40 minutes drive time and tapers off quite steeply to zero beyond around 80 miles. Their findings suggest that doubling mass raises productivity in a given area by 3.5%. They demonstrate their results to be robust and independent of any dominant effect of London and the South East. Just over a third (34%) of the predicted spatial variation in UK productivity[8] is attributable to variance in economic mass, compared to 46% that is due to variance in levels of qualification and other region-specific factors.[9] Removing Inner London increases this to 40%. Removing the most productive 25% of areas increases it to more than two-thirds – in other words, the effects of economic mass on productivity are greater in the less productive areas. This points to the importance of economic mass as a constituent of peripherality suggesting that it should be considered when constructing indices of peripherality. The study also suggests that the impacts of economic mass and by association peripherality, may not be linear – given that the effects of economic mass are greater in less productive and possibly more peripheral areas.

3.3. The European Peripherality Index (EPI) (Schurmann and Talaat, 2002) was developed in order to identify peripheral regions across the then 15 member states and 12 candidate countries which might be targeted for transport improvements under the Trans-European Transport Network initiative. The economic potential of a region was assumed to be a function of its economic 'mass' its proximity in terms of travel time to all other regions and their economic 'mass'. A range of different indicators were calculated at NUTS 3 level based on travel time by car and by lorry and with different mass terms including GDP, employment and population. Two of these are presented in appendix one, access to population by car and access to GDP by lorry.

3.4. Given the overall spatial definition of the study area at the European level, both indices display a strong centre/periphery pattern with above average accessibility centered on Benelux, Germany and northern France. The most peripheral, as would be expected, include Scandinavia, the Mediterranean islands, northern Scotland, Northern Ireland and the Republic of Ireland. Wales in below average in terms the first of these indices but only just – it is relatively close to the heartland of Europe in terms of travel time compared with more geographically peripheral areas. In terms of the second index, access to GDP by lorry it is actually slightly above average. The EPI is interesting in

[8] i.e. that part of total variation that is explained by the model..
[9] And a further 20% to covariance between economic mass and other observed variables.

methodological terms, pointing to the use of mass and travel time as components. Because, however, it is specifically focused at the European scale it does no provide much differentiation within the UK or within territories of the scale of Wales. Importantly as well, proximity to markets, employment and economic activity at a European scale are of relatively low importance as determinants of economic performance across the UK or within a territory such as Wales. In other words it is peripherality within the context of the England and Wales or the UK more generally that is likely to be of much greater relevance to the present study. What was needed, therefore, for the present study was an index of peripherality specific to the study area, namely England and Wales. It should also be noted that the present study set out to explain variation in GDP. Incorporating it in an index of peripherality, intended as an explanatory variable, would not therefore be appropriate.[10]

3.5. Initially, therefore, in order to examine the impacts of peripherality and remoteness on productivity, a range of indices were developed specifically for this study. Drawing on previous studies, two broad approaches were used. The two approaches provide alternative measures of what might be termed remoteness, dispersal or locational disadvantage.

3.6. The first measure which we term peripherality per se uses a gravity-model formulation based on the inverse of travel distance between places by road[11] and a measure of the potential of interaction between places based on mass in terms of population size. This index was built up at unitary authority/district-level across the whole of Wales and England. It provides a broadly-based index measuring what is commonly called economic mass or economic potential. It incorporates information on the size and location relative to all other places in Wales and England.

3.7. The second measure, which we term 'accessibility', provides a measure of local accessibility derived from of travel time to cities and towns within a defined range of any location.[12] It represents a more locally focused measure emphasising accessibility to centres of population, employment and economic activity within a maximum of two hours drive-time from any given location. This index was built up as a GIS data base providing measurements at the scale of a 1 km square. Average values were then derived at the level of unitary authorities/districts for the purposes of statistical analysis.

3.8. A further set of composite indices, combining the two – peripherality and accessibility was also derived and was included in subsequent versions of the analysis. These composite indices combined the two core indices with different weights to each (table 3.1) and were calculated at the level of unitary authorities/districts.

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[10] We would also suggest that it was not appropriate in the context of the EPI given that productivity is a measure of economic performance itself rather than of economic mass as measured for example by employment, which is commonly seen as one factor determining levels of economic performance.

[11] Based on Ordnance Survey data sets.

[12] Five time zones were constructed around each city (from 0-0.25 hours up to 1.5-2 hours) and two time zones around each town (<0.5 hours, 0.5-1.0 hours) based on network distance and average travel times on different classes of road. These were then combined to generate a single score, standardised to a scale of 1-10 for each location.

Table 3.1 : Structure of alternative composite indices

Index	Peripherality	Local Accessibility
1	0	100
2	100	0
3	50	50
4	25	75
5	75	25

3.9. As might be expected, there is a significant degree of similarity between the two base indices, peripherality and local accessibility. The degree of association between the two, a correlation of 0.52, clearly indicates however that the two indices measure different aspects of peripherality. The degree of association between the different indices including the composite measures is shown in table 3.2

Table 3.2: Correlations between alternative indices

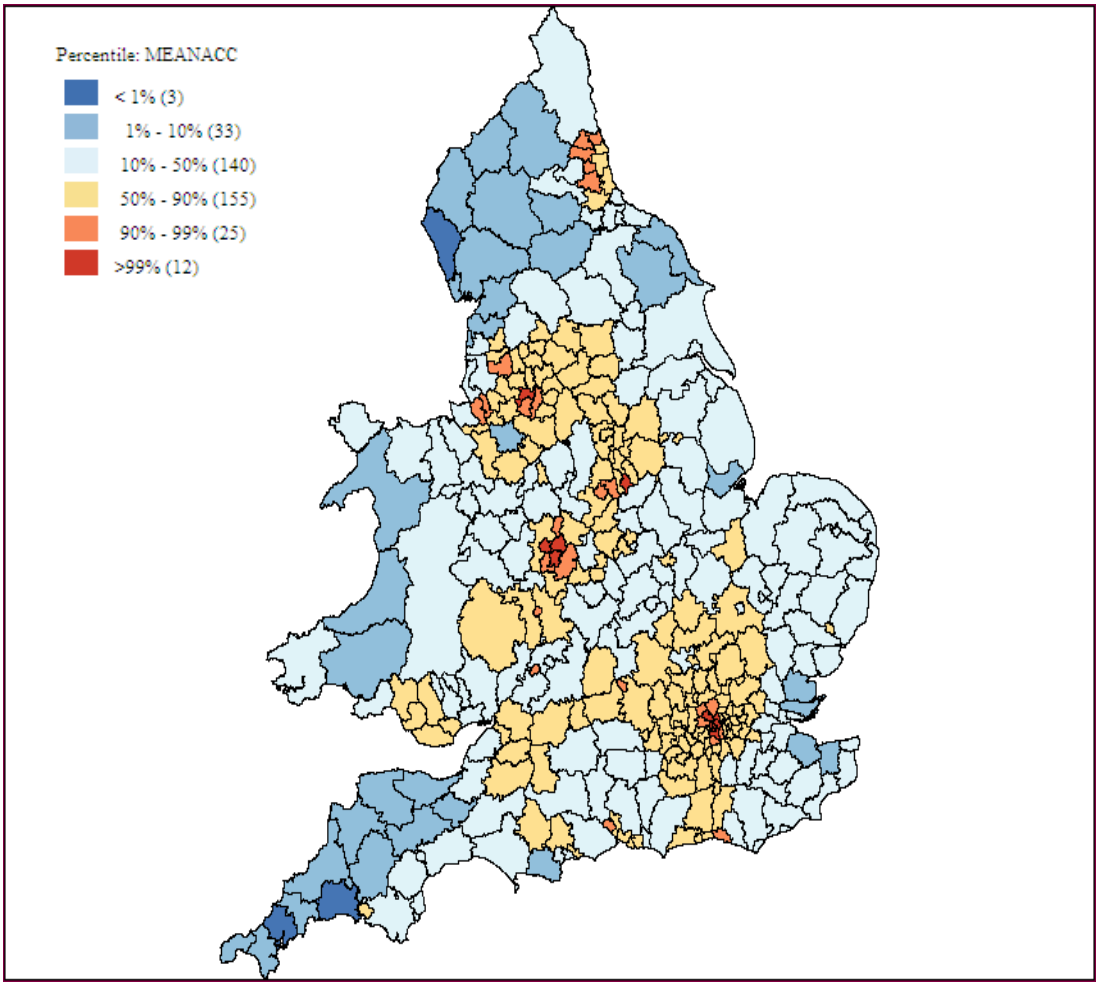
	Local Accessibility	Peripherality	50P:50A	25P:75A	75P:25A
Local Accessibility	1.000	–	–	–	–
Peripherality	0.515	1.000	–	–	–
50P:50A	0.957	0.698	1.000	–	–
25P:75A	0.993	0.595	0.985	1.000	–
75P:25A	0.847	0.811	0.965	0.905	1.000

n = 18,659

3.10. This demonstrates the relatively high correlation between most of the alternative measures, suggesting in turn that their explanatory power in relation to productivity may show little difference.

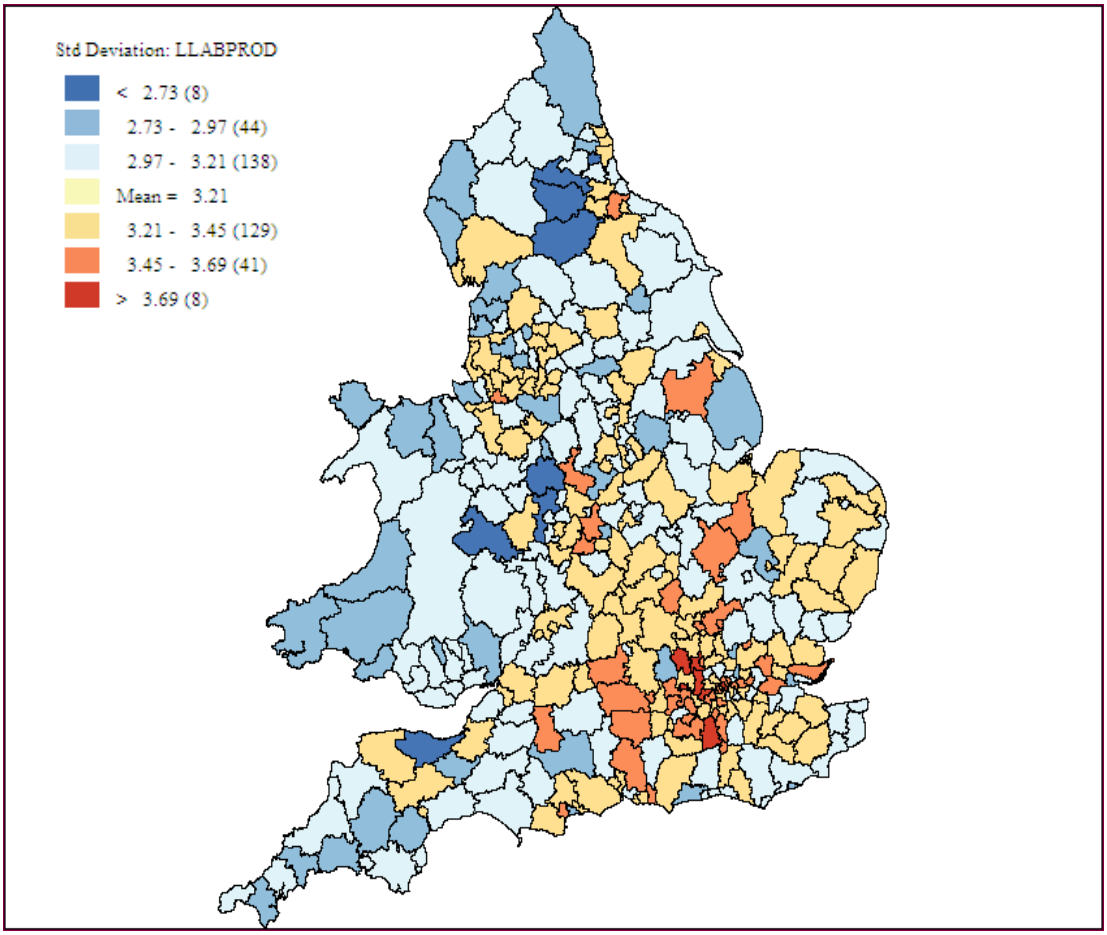
3.11. Figure 3.1 shows the pattern for the first of the indices listed in table 2.1, mean accessibility across England and Wales at a district/unitary authority level. It shows a general core-periphery pattern across England and Wales as a whole. It also however shows the influence of both London and the main conurbations and larger urban areas, leading to a poly-nuclear pattern. London, Birmingham, Manchester, the North-East and other major conurbations have high levels of accessibility. So too do much of the London commuter belt, the London-Brighton corridor and the M4 corridor. Cardiff and South Wales have relatively high levels of accessibility in an England and Wales context but fall short of the particularly high levels seen at the core of the English conurbations. The precise visual representation is influenced by the cut-off values selected but levels of accessibility in South Wales might be seen as an extension of the M4 corridor. The M50 effect does not however seem to extend into Wales to any great extent and most of Wales has similar levels of accessibility to the peripheral parts of England.

Figure 3.1: Standardised mean accessibility (standard deviation)



3.12. The pattern of accessibility presented above can usefully be looked at alongside the spatial pattern of productivity across England and Wales (figure 3.2) to allow a crude comparison of the two. This shows labour productivity at district/unitary-authority level based on the ONS plant-level data.

Figure 3.2: Labour productivity, England and Wales



3.13. As with accessibility there is, again, a broad centre-periphery pattern overall albeit with the highest values more clearly concentrated in and close to London. There are, again, higher values focused on the main conurbations and the M4 corridor is picked out. There would appear to be more of a concentration of areas with higher levels of labour productivity in the outer south-east and the London-Birmingham axis. The relatively low levels of productivity in Wales as a whole, in the context of England and Wales are evident with not even South Wales performing beyond the mean on this particular measure.

3.14. Additional maps for the three composite indices (3-5 in table 3.1) are presented in appendix two. These are based on the original data for the index of local accessibility, combined with the peripherality index and therefore provide information at a more detailed resolution of 1 km sq.

3.15. The analysis presented in section 4 below sets out to explore, statistically, the relationship between patterns of remoteness or locational disadvantage as measured by indices of peripherality, accessibility and combinations of the two, and labour productivity described visually in these figures. It seeks to identify the relationship between the two, along with the impacts of other key factors including capital stock and industrial structure.

4. THE DETERMINANTS OF PRODUCTIVITY DIFFERENTIALS

4.1. This section reports on the statistical analysis of factors determining spatial differentials in productivity, including the influence, specifically, of peripherality and accessibility. The analysis presented here uses plant level data held by the Office for National Statistics in the Annual Respondents Database (ARD2). This brings together a wide range of data relating to individual business units (ONS, 2002). The complete ARD2 data set includes all firms with greater than 250 employees in England (which are surveyed on an annual basis as a statutory requirement), but only a sample of firms with fewer than 250 employees. Smaller firms are sampled on a random basis (see ONS, 2002, p.2). This plant level assessment accounts for the numbers of plants within a firm by using the variable *llunit*, which is the log of the number of plants within the firm establishment. If the firm is a single plant establishment then this is equal to zero. GVA at factor cost per worker is used as the measure of productivity, measured at the plant (and therefore work-based) rather than the place of residence. It is important to note the level at which the data for the ARD2 are collected. This is the level of the plant and there may be more than one plant in a firm. In the analysis, the term 'plant' is therefore used, rather than 'firm' or 'business', as the base economic unit of the analysis. We also employ the most up to date data available at the present time – this is data for the year 2004.

4.2. Data on firm-specific capital stock is obtainable from the ONS and is matched with firm-specific data within the ARD2. Although this is not identical to the Treasury investment productivity driver (CURDs, 2003), it represents the result of past investments and is appropriate in modelling based on the Cobb-Douglas production function.

4.3. Tables 4.1 to 4.5 present the results of the analysis which, in each case seeks to explain productivity differentials in terms of peripherality/accessibility and other factors. Looking at table 4.1, column 1, initially, shows the effect of peripherality alone on labour productivity. Column 2 adds in capital stock, employment levels, the number of plants within firms and the part-time:full-time ratio. Column 3, finally, adds in industrial structure.

4.4. These first three columns relate only to the sample of plants that are located in Wales. Columns 4 to 6 repeat the analysis for all plants in Wales and England. The purpose of this approach is first to identify whether these explanatory variables are important for Welsh plants and then to identify whether the same explanatory variables are important for Welsh and English plants in general

4.5. Column 7, finally, presents the results of analysis to determine, statistically, whether there are significant differences between Wales and England in terms of different variables.[13] Two pieces of information are required to understand this

[13] Column 7 presents the results of a pseudo-chow test where the explanatory variables are clustered into two sets: the first set are headed England and these coefficients relate to England, the second set are headed Wales and these relate to the same variables but multiplied by one if the plant is located in Wales and zero otherwise. Regressions presented in column 7 on each table therefore seek to identify whether the effect of the variables differs between these two countries. Column 7 also has an additional statistic to identify whether we can delete the Welsh explanatory variables; this is important if these Welsh variables are not improving the model.

column. First, any coefficients in the Wales column with ***, ** or * are statistically significantly different for Wales than for England. Second, to identify whether the effect is stronger in Wales than in England we need to add the coefficients together.

4.6. Table 4.1 presents these results using mean accessibility as the index of peripherality (index 1 in table 3.1). Tables 4.2 to 4.5 present the same analysis but using different measures of peripherality in each case.

Initial findings

4.7. Looking first at table 4.1, there is clearly a statistically significant relationship between labour productivity and mean accessibility. This is to be expected given the broadly similar patterns displayed by the two variables in figures 3.1 and 3.2 above. The results suggest that plants that are located in areas that are more accessible are also more productive (column 1). However this may be artificially high because it is also capturing other effects that are associated with accessibility, such as the availability of workers. Column 2 introduces additional explanatory variables and the effect of accessibility on labour productivity does seem to reduce. Part of the spatial labour productivity divide associated with accessibility can therefore be partly attributable to the amount of capital stock, the size of the workforce, the effect of employing more part-time workers and the number of plants within the firm. Nevertheless we can still be sure that accessibility has a statistically significant influence on labour productivity, at the 99% confidence level. Column 3 introduces industrial structure and again the effect of accessibility appears to fall. Accessibility still appears to have an impact but the degree of confidence in this relationship is somewhat lower at just over 90%.

4.8. These results are repeated for England and Wales. Although similar results are generated several important differences should be highlighted. First the effect of accessibility on productivity appears to be consistently larger for the whole sample, suggesting that accessibility may be a smaller influence on labour productivity in Wales than in England. Second the amount of capital stock the plant has access to seem to have a relatively smaller effect on labour productivity in Wales than in England. Third, there may be more of a tendency to over-manning or above average use of labour relative to capital in Wales relative to England and Wales together – this may reflect lower costs of labour in more remote areas. Fourth part-time workers appear to have a larger detrimental effect on labour productivity in Wales than in England. Fifth, larger numbers of plant within a firm seems to allow Welsh plants to gain higher levels of labour productivity; this may be due to the sharing of knowledge, working practices, etc. However the opposite effect appears for the whole sample which probably is capturing the administrative and managerial complexities of running multiple plant firms. Finally, the magnitude of industrial dummy variables differs between the final columns. Relative to plants that operate in the all other industries, labour productivity of Welsh plants appear to be higher in any of the other sectors, and this enhancing effect is greater in Welsh plants than in the whole sample.

4.9. Another way to think about these results is the following. The effect of accessibility on labour productivity is positive, but part of this can be explained

by the plant's characteristics and the sector in which it operates. So, for example, plants across the accessibility continuum may well decide to alter their choice of techniques (such as their ratio of labour to capital) in order to offset the detrimental effect typically associated with accessibility. Plants operating in inaccessible areas may decide to employ greater proportions of cheap, part time workers than to invest in capital equipment which would take a long time to pay for due to their low levels of turnover. Plants operating in certain industries could also choose their location carefully so that increasing transportation costs do not reduce their ability to compete with plants located in the core of the market place. For instance, hotels and bed and breakfast companies may be able to charge higher prices for the 'experience' of being in a more inaccessible location, and these higher prices will in turn be reflected as higher value added and higher labour productivity levels.

4.10. Column 7 indicates that accessibility does not influence Welsh plants differently than for English plants. In general, Welsh plants are not statistically significantly affected by capital stocks and scale economies any differently than English plants. However the detrimental effect of greater proportions of part-time workers is greater. Plants operating in the transport and manufacturing sectors have significantly higher labour productivity rates than comparable plants in England. Relative to plants operating in other sectors, the detrimental effect of operating in the hotel and catering sector is much smaller, suggesting a relatively higher level of labour productivity in Welsh hotel and catering plants than in the English equivalents. It can be concluded from column 7 that, on average, there are important differences between Welsh and English plants, but that accessibility seems to have about the same effect.

Table 4.1: Mean accessibility

	Wales only			England and Wales			Wales different?	
	1	2	3	4	5	6	7	
							England	Wales
n	1,944	1,876	1,876	18,630	17,447	17,447	17,447	
Wales	–	–	–	–	–	–	–	0.030 (0.115)
Mean accessibility	**0.043***** **(0.012)**	**0.028***** **(0.010)**	**0.018*** **(0.010)**	**0.055***** **(0.004)**	**0.046***** **(0.004)**	**0.037***** **(0.003)**	**0.033***** **(0.004)**	0.016 (0.012)
Log (capital stock per worker)	–	0.241*** (0.013)	0.270*** (0.013)	–	0.260*** (0.004)	0.294*** (0.005)	0.293*** (0.005)	-0.023 (0.016)
Log (workers)	–	-0.015 (0.014)	-0.034** (0.014)	–	-0.011*** (0.004)	-0.009** (0.004)	-0.007 (0.004)	-0.027 (0.017)
Pt/ft ratio	–	-0.062*** (0.006)	-0.043*** (0.006)	–	-0.012*** (0.001)	-0.010*** (0.001)	-0.010*** (0.001)	**-0.033***** **(0.007)**
Log (plants)	–	0.050** (0.022)	0.042* (0.022)	–	-0.022*** (0.007)	-0.031*** (0.007)	-0.038*** (0.007)	**0.081***** **(0.027)**
Construction	–	–	0.384*** (0.070)	–	–	0.360*** (0.027)	0.348*** (0.028)	0.036 (0.086)
Wholesale	–	–	0.249*** (0.056)	–	–	0.218*** (0.019)	0.199*** (0.020)	0.050 (0.068)
Transport	–	–	0.249*** (0.074)	–	–	0.086*** (0.029)	0.064** (0.031)	**0.185**** **(0.092)**
Real estate	–	–	0.425*** (0.052)	–	–	0.376*** (0.020)	0.361*** (0.021)	0.064 (0.063)
Manufacturing	–	–	0.304*** (0.053)	–	–	0.089*** (0.020)	0.060*** (0.021)	**0.245***** **(0.065)**
Hotels	–	–	-0.544*** (0.065)	–	–	-0.772*** (0.030)	-0.796*** (0.033)	**0.251***** **(0.083)**
R^2	0.006	0.242	0.336	0.010	0.196	0.227	0.270	
F statistic	12.39***	119.16***	85.78***	190.08***	852.66***	576.59***	280.57***	
Test for Welsh variable collective deletion	–	–	–	–	–	–	7.02***	

Alternative measures of peripherality

4.11. Table 4.2 repeats the analysis but instead of using accessibility as our measure of geographical disconnectedness we employ the peripherality variable (Index 2 in table 3.2). As these variables are constructed in different ways we should expect different coefficient magnitudes. Nevertheless the important things to note here are the signs and the statistical stability of the results across the tables and across these geographical indicators. Major differences in these would indicate that the accessibility and peripherality variables are capturing very different things.

4.12. Several important points should be made when comparing Tables 4.1 and 4.2. First, after including plant characteristics and industrial dummies there appears to be no influence of peripherality on labour productivity in Wales, at least not at traditional levels of statistical significance. However this is not the case for the whole sample. Second, the magnitudes of the industry dummy coefficients are remarkably similar, suggesting that these industry variables have similar correlations and simultaneity bias with the geographical disconnectedness variables. The same parameter stability applies to all other variables. Third, the Welsh variables in column 7 are also very similar for both tables.

Table 4.2: Peripherality

	Wales only			England and Wales			Wales different?	
	1	2	3	4	5	6	England	Wales
n	1944	1876	1876	18,630	17,447	17,447	17,447	
Wales	–	–	–	–	–	–	–	-0.111 (0.093)
Peripherality	**0.0002**** **(0.0001)**	**0.0002**** **(0.0001)**	0.0001 (0.0001)	**0.0001***** **(0.000)**	**0.0001***** **(0.000)**	**0.00008***** **(0.000)**	**0.00007***** **(0.00001)**	0.000 (0.000)
Log (capital stock per worker)	–	0.242*** (0.013)	0.270*** (0.013)	–	0.262*** (0.004)	0.296*** (0.005)	0.295*** (0.005)	-0.024 (0.016)
Log (workers)	–	-0.015 (0.014)	-0.034** (0.014)	–	-0.009** (0.004)	-0.008* (0.004)	-0.005 (0.004)	**-0.029*** **(0.017)**
Pt/ft ratio	–	-0.063*** (-0.006)	-0.043*** (0.006)	–	-0.012*** (0.001)	-0.010*** (0.001)	-0.010*** (0.001)	**-0.033***** **(0.007)**
Log (plants)	–	0.050** (0.022)	0.043* (0.022)	–	-0.023*** (0.007)	-0.033*** (0.007)	-0.040*** (0.007)	**0.083***** **(0.027)**
Construction	–	–	0.387*** (0.070)	–	–	0.361*** (0.027)	0.346*** (0.028)	0.041 (0.086)
Wholesale	–	–	0.246*** (0.056)	–	–	0.218*** (0.019)	0.197*** (0.020)	0.049 (0.068)
Transport	–	–	0.251*** (0.074)	–	–	0.085*** (0.029)	0.062** (0.031)	**0.189**** **(0.092)**
Real estate	–	–	0.424*** (0.052)	–	–	0.386*** (0.020)	0.369*** (0.021)	0.055 (0.064)
Manufacturing	–	–	0.311*** (0.053)	–	–	0.088*** (0.020)	0.056*** (0.021)	**0.255***** **(0.065)**
Hotels	–	–	-0.545*** (0.065)	–	–	-0.777*** (0.030)	-0.799*** (0.033)	**0.254***** **(0.083)**
R^2	0.002	0.240	0.335	0.004	0.192	0.264	0.268	
F statistic	3.99**	118.25***	85.53***	71.02***	826.66***	567.30***	277.18***	
Test for Welsh variable collective deletion	–	–	–	–	–	–	8.54***	

Source: ONS

4.13. Table 4.3, 4.4 and 4.5 go on to replicate the analysis above with different weights attached to the core indices (indices 3-5 in table 3.1). Again, the results using different weightings of these variables are also shown to be very similar. This is not surprising given the similarity between the findings based on the two core indices.

4.14. In addition to the above, several important observations can be made taking tables 4.1-4.5 together. First, almost without exception, the different combinations of peripherality and accessibility are consistently statistically significant in driving labour productivity rates. The only exception is for the peripherality measure and then only when the extra explanatory variables are included in the regression results and for Wales on its own. This suggests that the influence of peripherality alone (index 1 in table 2.1) on Welsh labour productivity may be explained away by the inclusion of the extra explanatory variables. This may be because it is peripherality in relation to London and the South East and other major conurbations within England that matters and that once businesses have passed some threshold level of peripherality, any additional increase in peripherality has little impact.[14] On this specific measure, in effect the whole of Wales suffers the effects of peripherality with little distinction between different parts of the country.

4.15. This, however, is not the case for the accessibility variable. Based on this analysis, and because the aim of this analysis is partly to identify the influence of geographical disconnectedness on labour productivity, we move forward in this analysis by employing the accessibility variable alone as it is consistently a statistically significant driver of labour productivity.

[14] This is consistent with the study by Rice and Venables (2004) who found that the adverse effects of drive time fell off steeply after 80 miles.

Table 4.3: Mean accessibility and peripherality: 50:50

	Wales only			England and Wales			Wales different?	
	1	2	3	4	5	6	England	Wales
n	1,944	1,876	1,876	18,630	17,447	17,447	17,447	
Wales	–	–	–	–	–	–	–	0.008 (0.156)
50:50	**0.00007***** **(0.00002)**	**0.00005***** **(0.00001)**	**0.00003*** **(0.00001)**	**0.00007***** **(0.000)**	**0.0006***** **(0.000)**	**0.00005***** **(0.000)**	**0.00004***** **(0.000003)**	0.000 (0.000)
Log (capital stock per worker)	–	0.242*** (0.013)	0.271*** (0.013)	–	0.260*** (0.004)	0.295*** (0.005)	0.294*** (0.005)	-0.023 (0.016)
Log (workers)	–	-0.016 (0.014)	-0.034** (0.014)	–	-0.011** (0.004)	-0.009** (0.004)	-0.006 (0.004)	-0.028 (0.017)
Pt/ft ratio	–	-0.062*** (0.006)	-0.043*** (0.006)	–	-0.012*** (0.001)	-0.010*** (0.001)	-0.010*** (0.001)	**-0.033***** **(0.007)**
Log (plants)	–	0.051** (0.022)	0.042* (0.022)	–	-0.022*** (0.007)	-0.032*** (0.007)	-0.039*** (0.007)	**0.082***** **(0.027)**
Construction	–	–	0.383*** (0.070)	–	–	0.360*** (0.027)	0.347*** (0.028)	0.037 (0.086)
Wholesale	–	–	0.248*** (0.056)	–	–	0.217*** (0.019)	0.198*** (0.020)	0.050 (0.068)
Transport	–	–	0.249*** (0.074)	–	–	0.084*** (0.029)	0.062** (0.031)	**0.186**** **(0.092)**
Real estate	–	–	0.423*** (0.052)	–	–	0.377*** (0.020)	0.362*** (0.021)	0.061 (0.064)
Manufacturing	–	–	0.305*** (0.053)	–	–	0.089*** (0.020)	0.059*** (0.021)	**0.246***** **(0.065)**
Hotels	–	–	-0.545*** (0.065)	–	–	-0.774*** (0.030)	-0.797*** (0.033)	**0.253***** **(0.083)**
R^2	0.006	0.242	0.336	0.009	0.195	0.266	0.270	
F statistic	12.43***	119.45***	85.82***	162.93***	847.34***	574.08***	279.43***	
Test for Welsh variable collective deletion	–	–	–	–	–	–	4.53***	

Source: ONS

Table 4.4: Mean accessibility and peripherality: 75:25

	Wales only			England and Wales			Wales different?	
	1	2	3	4	5	6	England	Wales
n	1,944	1,876	1,876	18,630	17,447	17,447	17,447	
Wales	–	–	–	–	–	–	–	-0.084 (0.201)
75:25	**0.00009***** **(0.00003)**	**0.00007***** **(0.00002)**	**0.00004*** **(0.00002)**	**0.00008***** **(0.000)**	**0.0007***** **(0.000)**	**0.00005***** **(0.000)**	**0.00004***** **(0.000006)**	0.000 (0.000)
Log (capital stock per worker)	–	0.242*** (0.013)	0.271*** (0.013)	–	0.261*** (0.004)	0.295*** (0.005)	0.294*** (0.005)	-0.024 (0.016)
Log (workers)	–	-0.016 (0.014)	-0.035** (0.014)	–	-0.010** (0.004)	-0.008** (0.004)	-0.006 (0.004)	-0.029 (0.017)
Pt/ft ratio	–	-0.062*** (0.006)	-0.043*** (0.006)	–	-0.012*** (0.001)	-0.010*** (0.001)	-0.010*** (0.001)	**-0.033***** **(0.007)**
Log (plants)	–	0.051** (0.022)	0.043* (0.022)	–	-0.023*** (0.007)	-0.032*** (0.007)	-0.040*** (0.007)	**0.083***** **(0.027)**
Construction	–	–	0.384*** (0.070)	–	–	0.359*** (0.027)	0.345*** (0.028)	0.038 (0.086)
Wholesale	–	–	0.247*** (0.056)	–	–	0.216*** (0.019)	0.197*** (0.020)	0.050 (0.068)
Transport	–	–	0.249*** (0.074)	–	–	0.083*** (0.029)	0.061* (0.031)	**0.188**** **(0.092)**
Real estate	–	–	0.422*** (0.052)	–	–	0.380*** (0.020)	0.365*** (0.021)	0.057 (0.064)
Manufacturing	–	–	0.306*** (0.053)	–	–	0.088*** (0.020)	0.057*** (0.021)	**0.249***** **(0.065)**
Hotels	–	–	-0.545*** (0.065)	–	–	-0.776*** (0.030)	-0.799*** (0.033)	**0.254***** **(0.083)**
R^2	0.006	0.242	0.336	0.006	0.265	0.266	0.269	
F statistic	10.71***	119.46***	85.79***	118.92***	570.38***	574.08***	278.04***	
Test for Welsh variable collective deletion	–	–	–	–	–	–	4.65***	

Table 4.5: Mean accessibility and peripherality: 25:75

	Wales only			England and Wales			Wales different?	
	1	2	3	4	5	6	England	Wales
n	1,944	1,876	1,876	18,630	17,447	17,447	17,447	
Wales	–	–	–	–	–	–	–	0.033 (0.130)
25:75	**0.00005***** **(0.00001)**	**0.00004**** **(0.00001**	**0.00002*** **(0.00001)**	**0.00006***** **(0.000)**	**0.00005***** **(0.000)**	**0.00004***** **(0.000)**	**0.00004***** **(0.000004)**	0.000 (0.000)
Log (capital stock per worker)	–	0.242*** (0.013)	0.270*** (0.013)	–	0.260*** (0.004)	0.294*** (0.005)	0.293*** (0.005)	-0.023 (0.016)
Log (workers)	–	-0.015 (0.014)	-0.034** (0.014)	–	-0.011*** (0.004)	-0.009** (0.004)	-0.007 (0.004)	-0.027 (0.017)
Pt/ft ratio	–	-0.062*** (0.006)	-0.043*** (0.006)	–	-0.012*** (0.001)	-0.010*** (0.001)	-0.010*** (0.001)	**-0.033***** **(0.007)**
Log (plants)	–	0.051** (0.022)	0.042* (0.022)	–	-0.022*** (0.007)	-0.031*** (0.007)	-0.039*** (0.007)	**0.081***** **(0.027)**
Construction	–	–	0.384*** (0.070)	–	–	0.360*** (0.027)	0.348*** (0.028)	0.036 (0.086)
Wholesale	–	–	0.249*** (0.056)	–	–	0.218*** (0.019)	0.199*** (0.020)	0.050 (0.068)
Transport	–	–	0.249*** (0.074)	–	–	0.085*** (0.029)	0.063** (0.031)	**0.185**** **(0.092)**
Real estate	–	–	0.424*** (0.052)	–	–	0.376*** (0.019)	0.362*** (0.021)	0.063 (0.063)
Manufacturing	–	–	0.304*** (0.053)	–	–	0.089*** (0.020)	0.060*** (0.021)	**0.245***** **(0.065)**
Hotels	–	–	-0.545*** (0.065)	–	–	-0.773*** (0.030)	-0.796*** (0.033)	**0.252***** **(0.082)**
R^2	0.006	0.242	0.336	0.010	0.196	0.267	0.270	
F statistic	12.58***	119.29***	85.80**	182.72***	851.36***	575.86***	280.20***	
Test for Welsh variable collective deletion	–	–	–	–	–	–	4.49***	

Source: ONS

Accessibility and productivity – the shape of the relationship

4.16. The relationship between accessibility and productivity might take different forms. It could be a simple, linear relationship where a given increase in accessibility has a given impact on productivity whatever the actual level of the two variables. There are different theoretical reasons for different shapes of this relationship. For instance, a simple explanation might suggest that the relationship should be negative and linear and this would capture the influence of higher transportation costs on the ability to compete on price: greater distances increase transportation costs (in terms of fuel, time and operating costs), reduce the ability to charge lower prices and lower the measured added value in production.[15]

4.17. Alternatively, access may have strong effects where access is high but its impact may decrease as peripherality reaches higher levels. This would suggest a J shaped relationship with accessibility initially impacting strongly on productivity but tailing of in more peripheral areas.[16]

4.18. Thirdly, however, transportation costs can work in at least two ways: first they can reduce the ability of geographically disconnected plants to compete in the core of a market, but, second, they can reduce the ability of plants located in the core of the market to compete with plants in geographically disconnected locations (essentially geographically disconnectedness is insulating plants from competition) This might be reflected in higher prices and lower labour costs in more peripheral locations. Because of this two way effect the shape of the relationship between geographically disconnectedness and labour productivity may even be U-shaped. For these reasons the analysis went on to investigate the shape of the relationship between geographically disconnectedness and labour productivity.

4.19. Table 4.6 presents the same type of results as before but includes three accessibility variables: mean accessibility, orthoganolised mean accessibility squared and orthoganolised mean accessibility cubed to represent possible linear, J-shaped or U-shaped relationships. If, however, we were simply to include the square (and/or cube) of the accessibility variable then there would be a high degree of correlation and multicollinearity between the variables. For this reason the accessibility variables were orthoganolised at higher orders to avoid this econometric problem.

[15] Higher transport costs may of course to some extent be offset in more remote locations by lower costs of labour and premises. Lower wage costs may also explain lower capital stock relative to labour in more remote areas.

[16] Again consistent with Rice and Venables

Table 4.6: Simple and compound mean accessibility

	Wales only			England and Wales		
	1	2	3	4	5	6
n	1,944	1,876	1,876	18,630	17,447	17,447
Mean accessibility	0.042	0.051	0.050	**0.055*** **	**0.046*** **	**0.037*** **
	(0.043)	(0.037)	(0.035)	**(0.004)**	**(0.004)**	**(0.003)**
Orthoganolised mean accessibility[2]	-0.003	-0.005	-0.001	**0.006*** **	**0.004*** **	**0.005*** **
	(0.010)	(0.009)	(0.008)	**(0.002)**	**(0.002)**	**(0.001)**
Orthoganolised mean accessibility[3]	0.0004	0.005	0.006	**0.002*** **	0.001	**0.001***
	(0.007)	(0.006)	(0.006)	**(0.000)**	(0.001)	**(0.001)**
Log (capital stock per worker)	–	0.241***	-0.270***	–	0.260***	0.294***
		(0.013)	(0.013)		(0.004)	(0.005)
Log (workers)	–	0.015	-0.034**	–	-0.011***	-0.010**
		(0.014)	(0.014)		(0.004)	(0.004)
Pt/ft ratio	–	-0.062***	-0.043***	–	-0.012***	-0.010***
		(0.006)	(0.006)		(0.001)	(0.001)
Log (plants)	–	0.050**	0.042*	–	-0.022***	-0.031***
		(0.022)	(0.022)		(0.007)	(0.007)
Construction	–	–	0.383***	–	–	0.364***
			(0.070)			(0.027)
Wholesale	–	–	0.245***	–	–	0.218***
			(0.056)			(0.019)
Transport	–	–	0.246***	–	–	0.089***
			(0.074)			(0.029)
Real estate	–	–	0.423***	–	–	0.377***
			(0.052)			(0.019)
Manufacturing	–	–	0.308***	–	–	0.094***
			(0.053)			(0.020)
Hotels	–	–	-0.546***	–	–	-0.774***
			(0.065)			(0.030)
R^2	0.006	0.242	0.337	0.011	0.197	0.267
F statistic	4.16***	85.21***	72.64***	69.41***	610.45***	489.51***

Source: ONS

4.20. Table 4.6 reiterates the main findings from earlier tables as it emphasises the stability of the relationships between the extra explanatory variables and labour productivity; this is the case for England and Wales and for Wales on its own.

4.21. Of particular interest, however, is the relationship between accessibility and labour productivity. Columns 1-3 show that the more complex shapes of the relationship between accessibility and labour productivity seem to be watering down the general relationship; this is only the case for Wales and this might be because of a relatively small sample of plants.

4.22. The simple linear relationship between accessibility and labour productivity remains for the whole sample even when more complex interactions are also included in the equation. Almost without exception all accessibility variable coefficients are statistically significant at least at the 90% confidence level; all coefficients are positive.

4.23. Table 4.7 presents three sets of econometric results which further explore the shape of the relationship between accessibility and labour productivity. The purpose of this is to identify whether the shape of the relationship between accessibility variables and labour productivity varies with the inclusion of extra explanatory variables and whether the shape of the relationship is different for Wales when compared to England.

4.24. Columns 1-3 all illustrate that we can not be sure the relationship between accessibility and labour productivity is different between Wales and England; this is the case throughout the augmentation of the model with the extra explanatory variables. It is pleasing to note the consistency of the results for the other variables, including the Welsh variables, as this indicates stability in our results.

Table 4.7: Are Welsh plants different than English plants? – Whole sample, Welsh dummy variables

	1		2		3	
	England	Wales	England	Wales	England	Wales
n	18,630		17,447		17,447	
Wales	–	-0.175 (0.330)	–	-0.199 (0.294)	–	-0.204 (0.283)
Mean accessibility	**0.047***** **(0.004)**	-0.004 (0.049)	**0.039***** **(0.004)**	0.012 (0.042)	**0.032***** **(0.004)**	0.018 (0.041)
Orthoganolised mean accessibility^2	**0.004**** **(0.002)**	-0.007 (0.012)	0.003 (0.002)	-0.008 (0.010)	**0.004***** **(0.002)**	-0.006 (0.010)
Orthoganolised mean accessibility^3	**0.002***** **(0.001)**	-0.002 (0.008)	0.001 (0.001)	0.004 (0.007)	**0.001**** **(0.001)**	0.005 (0.007)
Log (capital stock per worker)	–	–	0.258*** (0.005)	-0.017 (0.015)	0.292*** (0.005)	-0.022 (0.016)
Log (workers)	–	–	-0.009 (0.004)	-0.006 (0.017)	-0.007* (0.004)	-0.027 (0.017)
Pt/ft ratio	–	–	-0.011*** (0.001)	**-0.051***** **(0.007)**	-0.010*** (0.001)	**-0.033***** **(0.007)**
Log (plants)	–	–	-0.032*** (0.007)	**0.082***** **(0.026)**	-0.038*** (0.007)	**0.081***** **(0.027)**
Construction	–	–	–	–	0.352*** (0.028)	0.031 (0.086)
Wholesale	–	–	–	–	0.200*** (0.020)	0.044 (0.068)
Transport	–	–	–	–	0.067** (0.031)	**0.180**** **(0.092)**
Real estate	–	–	–	–	0.362*** (0.021)	0.061 (0.063)
Manufacturing	–	–	–	–	0.064*** (0.021)	**0.244***** **(0.066)**
Hotels	–	–	–	–	-0.798*** (0.033)	**0.251***** **(0.082)**
R^2	0.014		0.203		0.271	
F statistic	37.94***		295.41***		239.57***	
Test for Welsh variable collective deletion	14.19***		16.06***		4.19***	

Source: ONS

Further analysis of sectoral differences – comparing Wales and England

4.25. Given the identification of differences in labour productivity rates across sectors between Wales and England, it may be worthwhile identifying whether accessibility is one of the important drivers of this difference. Accordingly, Table 4.8a and 4.8b present results where the sample is split so that we examine each sector in turn. Here the samples include all plants in a sector in both Wales and England.

4.26. Analysis of plants operating in the construction, wholesale and retail, transport and communications and real estate sectors are presented in Table 9a while plants in the manufacturing, hotels and catering and other sectors are presented in Table 9b. Here we are attempting to identify whether accessibility influences Welsh plants in a different way than English based plants. The coefficients with stars are statistically significant at traditional confidence levels. By way of illustration consider the results specifically for the construction and manufacturing industries. In the construction industry labour productivity appears to be influenced by capital stocks and part-time workers; this is also the case in Wales. The coefficients in the Wales column suggest that construction in Wales is not statistically different than in England (shown by the lack of statistical significance on the 'Wales' variable). However labour productivity in construction plants in Wales does seem to suffer from greater proportions of part time workers.

4.27. Manufacturing plants appear to have higher labour productivity levels if they also have greater capital stocks, more workers and lower proportions of part-time workers; such plants are also affected by accessibility. Welsh manufacturing plants can be seen to be much more productivity the more accessible they are, and this effect is much stronger and more statistically significant when compared to English plants. Welsh manufacturing plants also appear to suffer from diseconomies of scale and are adversely affected to a greater extent by greater proportions of part-time workers. It is also clear that manufacturing plants in Wales are less productive than English plants (as shown by the 'Wales' coefficient).

4.28. Several general observations can be made, based on the results presented in Tables 3.8a and 3.8b. First, accessibility appears to have no effect on labour productivity of firm operating in the construction and transport sectors. On the other hand, greater accessibility increases productivity for all plants operating in the wholesale, real estate and other sectors.

4.29. Second, in terms of the shape of the relationship between productivity and accessibility in the different sectors, greater accessibility does not appear to increase labour productivity in a linear fashion in manufacturing plants in England but it does for plant in Wales; indeed there is a cubic-shaped effect which is small and negative in England and larger and positive for Welsh plants.

4.30. Greater accessibility increases labour productivity in a linear and squared fashion for plants operating in the hotel and catering sector in England. This linear effect is much stronger and negative for such plants in Wales, and now there is a significant negative cubic effect. These shapes may be reflecting the large coverage of these aggregate industrial sectors; English plants may have higher GVA (and charge higher prices) if they are located near to the centre of conurbations whereas hotel

and catering plants in Wales might have higher GVA (and charge higher prices) if they are more inaccessible.

4.31. Third, the enhancing effects of capital stocks are greater for plants in the transport sector and smaller for real estate plants in Wales relative to plants in England.

4.32. Fourth, greater proportions of part-time workers seem to have larger adverse effects on labour productivity in Wales than in England for plants operating in the construction and smaller but still statistically significant and negative effects in Wales in the wholesale and hotel and catering sectors.

4.33. Finally, manufacturing sector plants are much less productive in Wales than in England, while the opposite is the case for plants in the hotel and catering sector.

Table 4.8a: Are Welsh plants different from English plants by sector? England and Wales, specific sectors, Welsh dummy variables

	Construction		Wholesale		Transport		Real estate	
n	1370		4126		1045		3745	
	England	Wales	England	Wales	England	Wales	England	Wales
Wales	–	-0.286 (0.840)	–	-0.815 (0.761)	–	-1.119 (0.996)	–	-0.087 (0.642)
Mean accessibility	-0.005 (0.010)	0.046 (0.121)	**0.028***** **(0.007)**	0.072 (0.107)	0.003 (0.014)	0.101 (0.142)	**0.050***** **(0.009)**	0.024 (0.091)
Orthoganolised mean accessibility^2	-0.006 (0.004)	0.016 (0.027)	-0.002 (0.003)	0.004 (0.025)	0.006 (0.006)	-0.016 (0.033)	0.003 (0.004)	-0.014 (0.022)
Orthoganolised mean accessibility^3	-0.003 (0.002)	-0.004 (0.020)	0.001 (0.001)	0.008 (0.018)	-0.002 (0.003)	0.018 (0.023)	**0.003**** **(0.002)**	0.011 (0.016)
Log (capital stock per worker)	0.244*** (0.014)	-0.076 (0.049)	0.293*** (0.011)	-0.001 (0.045)	0.255*** (0.017)	**0.113*** **(0.068)**	0.322*** (0.008)	**-0.049*** **(0.029)**
Log (workers)	0.004 (0.011)	0.034 (0.043)	0.049*** (0.010)	0.057 (0.045)	0.069*** (0.016)	-0.034 (0.059)	-0.066*** (0.008)	-0.019 (0.037)
Pt/ft ratio	-0.339*** (0.067)	**-0.965**** **(0.416)**	-0.132*** (0.011)	**0.086***** **(0.028)**	-0.027*** (0.006)	-0.020 (0.033)	-0.006*** (0.001)	-0.021 (0.013)
Log (plants)	0.041 (0.025)	-0.189 (0.119)	-0.111*** (0.014)	-0.045 (0.059)	-0.119*** (0.027)	0.081 (0.109)	0.024 (0.015)	-0.007 (0.061)
R^2	0.252		0.272		0.254		0.384	
F statistic	30.34***		102.36***		23.41***		155.27***	
Test for Welsh variable collective deletion	3.51***		2.05**		0.69		1.51	

Source: ONS

Table 4.8b: Are Welsh plants different from English plants by sector? England and Wales, specific sectors, Welsh dummy variables

	Manufacturing		Hotels		Other sectors	
n	3545		1015		3154	
	England	Wales	England	Wales	England	Wales
Wales	–	**-1.078**** **(0.509)**	–	**1.745***** **(0.789)**	–	0.380 (0.703)
Mean accessibility	0.004 (0.006)	**0.193***** **(0.074)**	**0.026**** **(0.013)**	**-0.234**** **(0.108)**	**0.072***** **(0.011)**	-0.024 (0.103)
Orthoganolised mean accessibility^2	-0.003 (0.003)	0.019 (0.017)	**0.011*** **(0.006)**	-0.015 (0.027)	**0.016***** **(0.005)**	-0.023 (0.025)
Orthoganolised mean accessibility^3	**-0.002*** **(0.001)**	**0.031***** **(0.011)**	-0.002 (0.002)	**-0.034**** **(0.017)**	**0.005**** **(0.002)**	0.003 (0.016)
Log (capital stock per worker)	0.208*** (0.011)	0.011 (0.029)	0.272*** (0.028)	0.004 (0.082)	0.237*** (0.014)	-0.001 (0.044)
Log (workers)	0.058*** (0.008)	**-0.066**** **(0.028)**	0.057*** (0.019)	**-0.098*** **(0.058)**	-0.058*** (0.012)	**-0.151***** **(0.053)**
Pt/ft ratio	-0.087*** (0.015)	**-0.422***** **(0.107)**	-0.073*** (0.009)	**0.052***** **(0.017)**	-0.035*** (0.004)	-0.023 (0.015)
Log (plants)	-0.013 (0.016)	**0.140**** **(0.057)**	0.058** (0.029)	0.121 (0.086)	0.021 (0.021)	**0.290***** **(0.070)**
R^2	0.170		0.202		0.182	
F statistic	48.25		16.86***		46.42***	
Test for Welsh variable collective deletion	3.83***		2.43**		4.43***	

Source: ONS

Sectoral differences within Wales

4.34. Given this evidence it is worth asking whether sectors are affected by accessibility differently within Wales. The analysis presented in tables 4.9a and 4.9b is based on the sample of firms in Wales on its own and seeks to identify whether plants in a specific sector differ from firms in other sectors within Wales. Again a couple of points are worthy of note.

4.35. First, initially it appears that accessibility does not influence labour productivity rates for different sectors in different ways. However when we separate the sample to identify whether the accessibility factor influences Welsh plants in the hotel and catering sector differently than the average sector in Wales, we find that this division is statistically significant and that accessibility does seem to increase labour productivity in a linear and cubic fashion. There are opposite effects for plants in the hotel and catering sector than in all other sectors. Again these shapes may be indicating that greater accessibility is generally a beneficial thing for the average Welsh plant but it is detrimental for the Welsh hotel and catering plant.

4.36. Second, these results suggest that the part-time worker issue is particularly detrimental for labour productivity in the construction and manufacturing sectors in Wales, whereas it is weaker for plants in the real estate and hotel and catering sectors.

Table 4.9a: Are different sectors within Wales affected by accessibility differently?

	Construction		Wholesale		Transport		Real estate	
	All sectors	Construction	All sectors	Wholesale	All sectors	Transport	All sectors	Real estate
Industry dummy	–	0.527 (1.047)	–	-0.790 (0.750)	–	-0.970 (1.052)	–	0.261 (0.642)
Mean accessibility	0.053 (0.038)	-0.012 (0.150)	0.032 (0.040)	0.057 (0.106)	0.044 (0.038)	0.060 (0.150)	0.032 (0.041)	0.043 (0.092)
Orthoganolised mean accessibility^2	-0.006 (0.009)	0.016 (0.033)	-0.007 (0.009)	0.009 (0.024)	-0.006 (0.009)	-0.004 (0.035)	-0.008 (0.010)	-0.003 (0.022)
Orthoganolised mean accessibility^3	-0.006 (0.006)	-0.012 (0.024)	0.002 (0.006)	0.006 (0.018)	0.004 (0.006)	0.012 (0.025)	0.002 (0.006)	0.013 (0.016)
Log (capital stock per worker)	0.248*** (0.013)	-0.080 (0.059)	0.236*** (0.014)	-0.001 (0.045)	0.234*** (0.013)	**0.134*** **(0.069)**	0.261*** (0.015)	0.012 (0.030)
Log (workers)	-0.017 (0.015)	0.056 (0.053)	-0.025 (0.016)	**0.130***** **(0.043)**	-0.020*** (0.015)	0.054 (0.061)	-0.003 (0.016)	**-0.082**** **(0.037)**
Pt/ft ratio	-0.060*** (0.006)	**-1.245**** **(0.497)**	-0.063*** (0.007)	0.017 (0.028)	-0.063*** (0.006)	0.016 (0.034)	-0.073*** (0.007)	**0.046***** **(0.014)**
Log (plants)	0.058*** (0.022)	-0.206 (0.143)	0.093*** (0.027)	**-0.249***** **(0.059)**	0.057** (0.023)	-0.094 (0.111)	0.047* (0.024)	-0.029 (0.059)
R^2	0.251		0.252		0.246		0.268	
F statistic	41.65***		41.75***		40.34***		45.29***	
Test for industry variables collective deletion	2.92***		3.06***		1.05		8.09***	

n = 1,876; Source: ONS

Table 4.9b: Are different sectors within Wales affected by accessibility differently?

	Manufacturing		Hotels		Other Sectors	
	All sectors	Manufacturing	All sectors	Hotels	All sectors	Other Sectors
Industry dummy	–	-0.867 (0.667)	–	1.278 (0.802)	–	0.412 (0.584)
Mean accessibility	0.051 (0.041)	0.145 (0.097)	**0.099***** **(0.037)**	**-0.307***** **(0.112)**	0.050 (0.041)	-0.009 (0.085)
Orthoganolised mean accessibility^2	-0.004 (0.010)	0.017 (0.022)	-0.003 (0.009)	-0.002 (0.027)	0.002 (0.010)	-0.012 (0.020)
Orthoganolised mean accessibility^3	0.004 (0.007)	**0.025*** **(0.015)**	**0.013**** **(0.006)**	**-0.048***** **(0.018)**	0.004 (0.007)	0.004 (0.014)
Log (capital stock per worker)	0.214*** (0.015)	0.006 (0.035)	0.270*** (0.013)	0.007 (0.077)	0.222*** (0.014)	0.008 (0.022)
Log (workers)	- 0.052*** (0.017)	0.045 (0.037)	-0.027* (0.014)	-0.014 (0.055)	0.018 (0.015)	**-0.220***** **(0.040)**
Pt/ft ratio	- 0.059*** (0.006)	**-0.450***** **(0.128)**	- 0.055*** (0.007)	**0.035**** **(0.016)**	- 0.060*** (0.008)	0.003 (0.013)
Log (plants)	0.088*** (0.025)	0.039 (0.070)	0.043* (0.022)	0.020 (0.083)	-0.014 (0.025)	**0.318***** **(0.055)**
R^2	0.260		0.312		0.275	
F statistic	43.47***		56.30***		46.91***	
Test for industry variables collective deletion	5.50***		23.74***		10.39***	

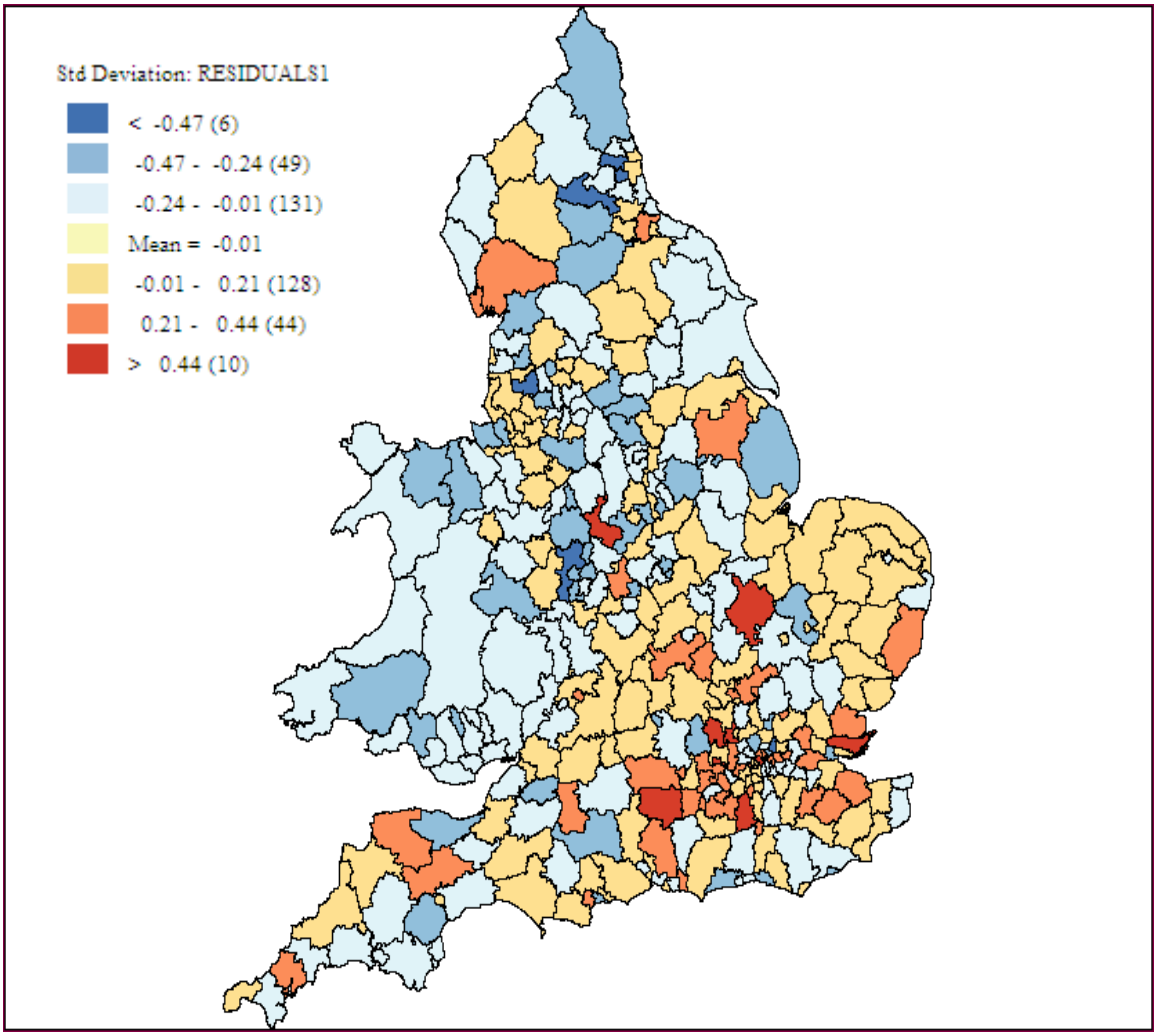
Further analysis of the spatial pattern of productivity differentials: exploratory analysis of the residuals from the regression model

4.37. The next stage of the analysis was to start to analyse spatial patterns of productivity differentials by looking at the residuals from the statistical models. This involved deriving from the analysis, spatial patterns of residuals from the econometric model. It was then possible to identify those geographical areas where levels of productivity diverged in particular from those predicted by the model. The analysis of spatial patterns of residuals from regression is a well established approach. It has not, so far as we know, been applied to the analysis of productivity and competitiveness over space.

4.38. In simple visual terms figure 3.1, presented earlier, shows the spatial pattern of accessibility across England and Wales and figure 3.2, the pattern of labour productivity. The analysis presented in table 4.1, column 1 showed the relationship between accessibility and labour productivity. This simple model in effect attempts to predict levels of productivity, using accessibility as the explanatory variable for every district/unitary authority across England and Wales (aggregated from the results for each plant within each spatial unit). It does so with some degree of success – in the sense that the model identifies a statistically significant relationship. It captures or predicts a certain amount of the variation in productivity based on levels of accessibility alone.

4.39. Although the model appears to perform well, when we map the residuals it becomes clear that there is a spatial element of productivity which the model has failed to capture. These differences or residuals, can be measured and standardised to present a picture of how successfully the model predicts levels of productivity for each spatial unit. They can also be presented graphically in map-form to identify any spatial patterns in the effectiveness of the model, as shown in figure 4.1.

Figure 4.1 : Standardised residuals[17] from regression model relating productivity to accessibility (table 3.1 column 1).

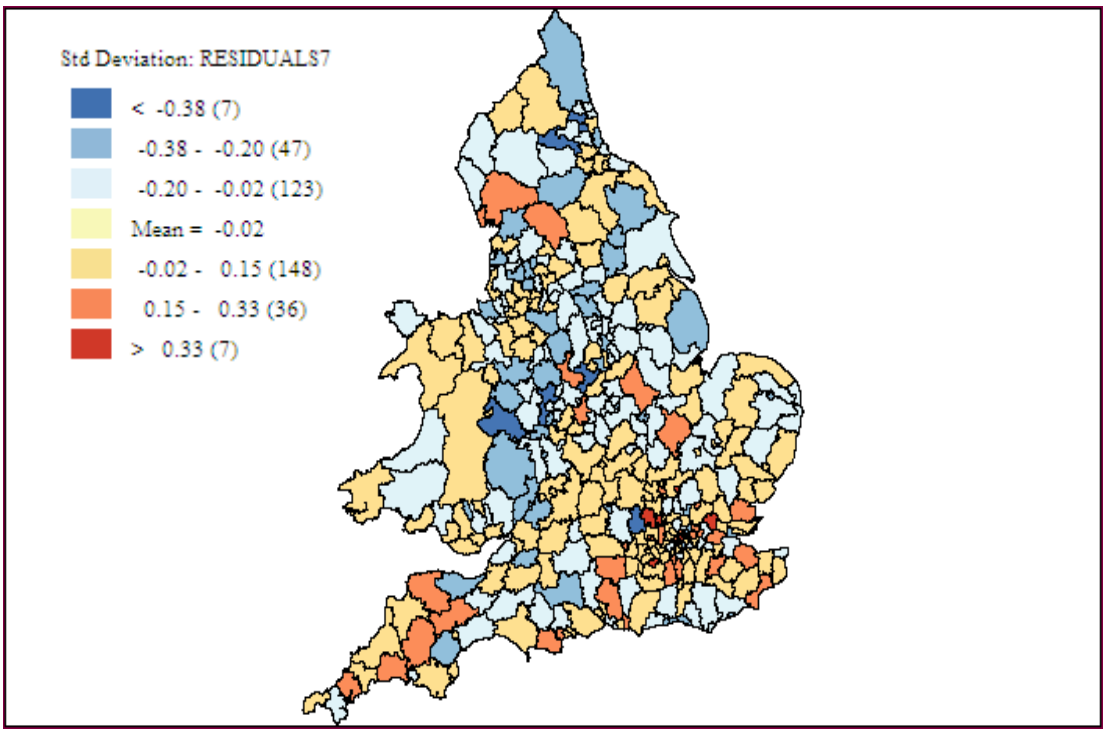


[17] Expressed as standard deviations

4.40. It can be seen from Figure 4.1 that there are large areas where the initial model consistently over-predicts the average level of labour productivity. This is particularly the case across much of Wales, as shown by the blue areas. There are also areas where the average level of labour productivity is consistently under-predicted. These are particularly in areas around London, and the main conurbations although not exclusively. This simple model is therefore over-predicting productivity in areas of low productivity and under-predicting it where it is high. Put more simply the good areas are even better than the model predicts and the bad areas worse.

4.41. However these results only take accessibility into account. Figure 4.2 presents a map of the residuals from the full model including the Welsh variables (table 3.1, column 7). The spatial distribution of the residuals now appears to be somewhat more random. The picture across Wales, specifically, is now more varied, with productivity in some areas slightly under-predicted but in others slightly over-predicted. There is still on balance more of a tendency, however to over-predict including a cluster of authorities in SE Wales and a broader north-south swathe. This suggests that the statistical model, including accessibility and other factors, is explaining the overall pattern of variation in productivity quite well but that there are still important spatial effects that have been omitted from the model. The final stage of the analysis presented in section 4, following, attempts to capture these effects.

Figure 4.2: Standard deviation of residuals for regression table 4.1



5. EXPLORATORY SPATIAL ANALYSIS

5.1. This technical section goes on to present a further stage in the analysis that explicitly incorporates spatial relationships into the model. In doing so it goes one step beyond what was included in the project brief – those of a less technical background may wish to move on to section seven which presents the main findings and discusses policy implications.

5.2. The econometric modelling process presented so far assumes that firms are independent and not influenced by other firms that are close to them. Standard non-spatial analysis in fact assumes that this is the case – demonstrated by a lack of systematic spatial patterns in the residuals from the analysis ('spatial autocorrelation). If this assumption is not met then the statistical model is likely to be less dependable than it might be (Bailey and Gatrell, 1995).

5.3. This implicit assumption may be incorrect if spatial spillovers between spatially-clustered firms and geographically close or contiguous areas do significantly affect labour productivity. This might be the case if the productivity of a particular firm is boosted in some way by its physical proximity to and interaction with neighbouring firms. And vice versa, that a firm's productivity may suffer it is close to other firms with low productivity.

5.4. This section attempts to identify whether there are such spatial variations in labour productivity levels across Wales and England by empirically identifying whether there is a significant degree of correlation in levels of productivity across space. We attempt explicitly to account for this 'spatial autocorrelation' in subsequent spatial econometrics.

5.5. One of the clearest expositions of the reasons why residuals can be spatially autocorrelated has been provided by Voss *et al*. (2006), based on the work by Wrigley *et al*. (1996), who emphasise the importance of, amongst other things, *feedback*, *grouping forces* and *grouping responses*.

5.6. Voss *et al*. (2006) state the potential for *feedback* forces to influence individuals and households preferences and activities. This is equally likely to be the case for firms as they are perhaps even more affected by related forces such as competition. *Ceteris paribus*, the smaller the spatial scale of analysis then the greater the potential feedback because of the higher likelihood and frequency of contact between firms. For reasons related to the adoption/diffusion theory (Rodger, 1962) and the agent interaction theory (Irwin and Bockstael, 2004), we should expect there to be the potential for spillovers of labour productivity values with a positive correlation in labour productivity between contiguous districts or unitary authorities. Feedback forces describe potential interactions between firms. Greater competition may stimulate innovation with positive impacts on productivity. Opportunities for spatial interaction and collaboration between spatially proximate firms may stimulate productivity.

5.7. Firms in geographically proximate local authority districts, might be also be influenced by *grouping forces*. Clusters of high average labour productivity values might be due to a firm in a particular locality benefiting in a similar way from proximity to sources of skills and expertise, innovation or business advice and support. This may be particularly the case for areas with similar industry

compositions where firms in the same industry are effectively grouping together in space.

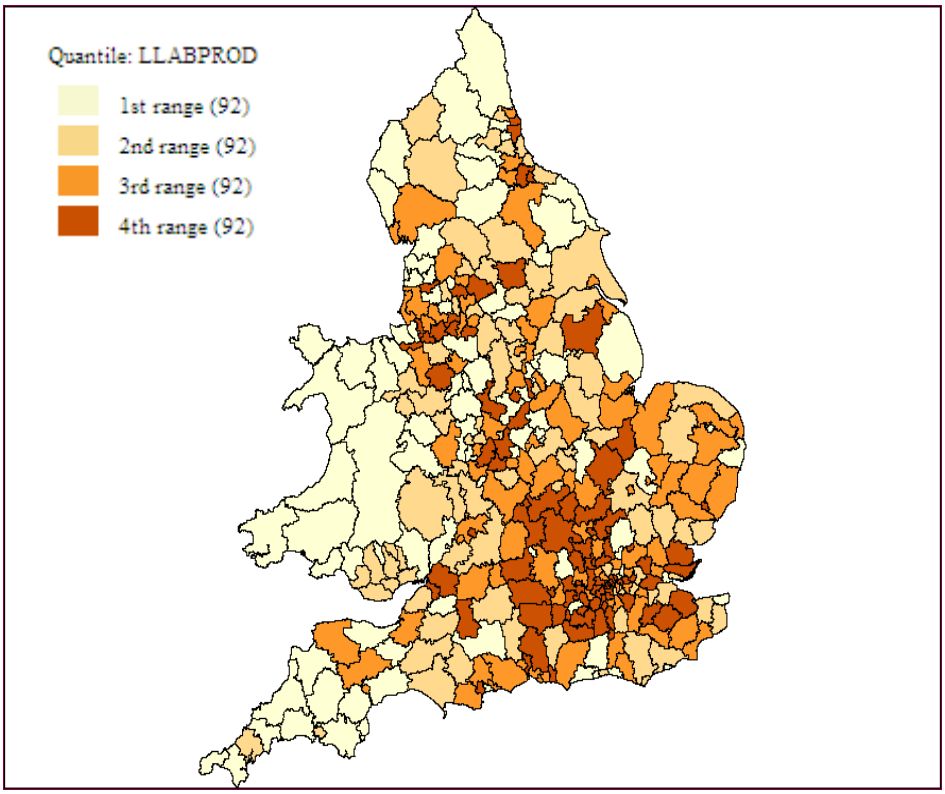
5.8. Mean values were derived from the original data sets for labour productivity and for the set of explanatory variables identified earlier for unitary authorities/districts across England and Wales. Where any area has less than 10 firms it was clustered with an adjacent area in order to ensure confidentiality of data.

Labour productivity

5.9. Figure 5.1 presents a quantile map of labour productivity across Wales and England; the sample is separated into four evenly sized groups where the local authorities with the highest average labour productivity have the darkest shade. Several observations can be made. First, much of Wales, as would be expected, is shown to have relatively low average labour productivity levels. The highest average labour productivity areas in Wales are clustered around the Cardiff-Newport area. Second, South West England also appears to have a dominance of areas that also have low average labour productivity values. Third, high labour productivity areas are clustered around the London area and large urban areas.

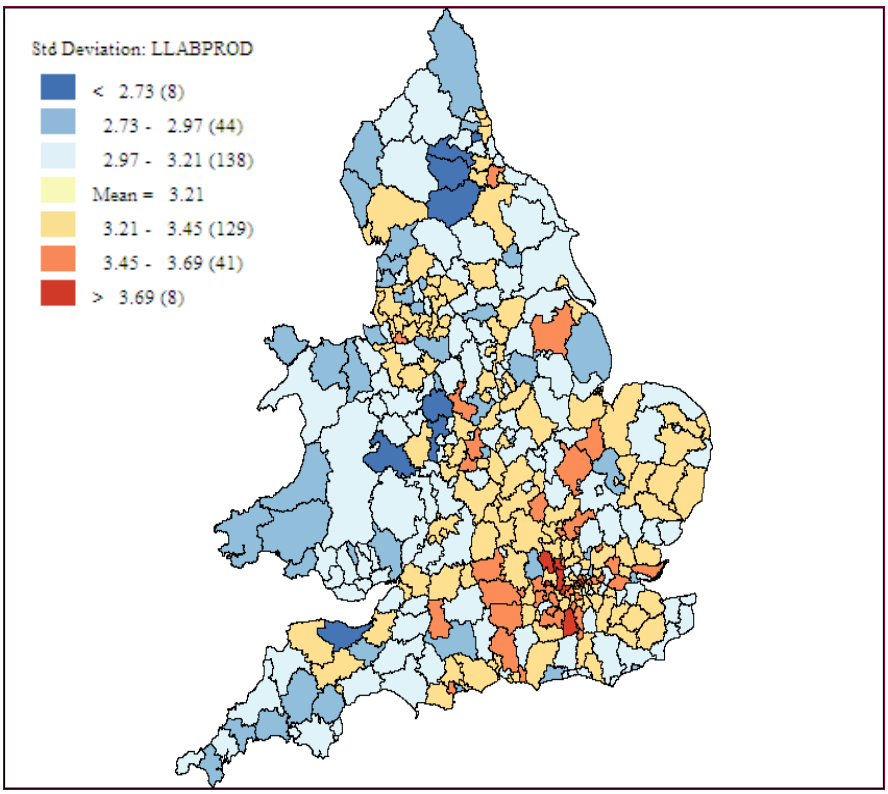
5.10. Although this is one of the clearest ways of presenting such data, there are several problems with presenting the data in this way. For instance the map will highlight areas in different colours if they are on the cusp of the bins (such as the 24th and 26th percentile).

Figure 5.1: Quantile map of labour productivity



5.11. Figure 5.2 expresses the same data in terms of standard deviation around the mean and allows more detail to be presented whilst ensuring confidentiality is maintained. Similar observations can be made as with figure 5.1. There are areas of particularly high and particularly low average labour productivity and large areas where the average labour productivity is fairly similar. Although much of Wales appears to have a relatively low labour productivity level, it does not include areas at the bottom of the rankings.

Figure 5.2: Standard deviation of labour productivity



To identify if there is the possibility of spatial effects present in the data, the next step is to employ a spatial weight matrix. Throughout our spatial estimates we will employ a queen contiguity spatial weight matrix. Queen contiguity spatial weight matrices allow the identification of any association between the value of an observation in a particular area and those for contiguous areas as defined by the matrix. As an example, consider area A in the map below. It has eight areas which are contiguous marked with either a C or and R. If we were to use a Castle weight contiguity matrix then we would only be considering those area which are contiguous along area A's sides. An alternative is to employ a rook contiguity weight matrix which only considers points at corners. A more appropriate contiguity weight matrix in our case is the queen contiguity weight matrix which takes into account all bordering contiguous areas.

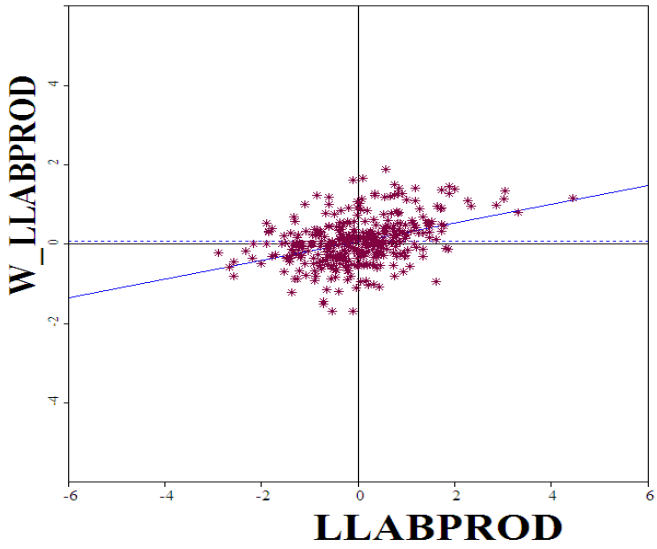
R	C	R
C	A	C

R | C | R

5.12. Figure 5.3 presents a scatter plot that correlates each area's labour productivity on the horizontal axis with their contiguous areas average labour productivity on the vertical axis. There is a regression line through the sample of points, where each point represents a distinct district or unitary authority. The slope of the regression line is often referred to as the Moran's I statistic. In Figure 3 gradient of the slope is 0.2363. This Moran's I is statistically significant at the 99% confidence level, suggesting this relationship is highly unlikely to have occurred by chance. It appears that areas with higher labour productivity values do have contiguous areas that also have relatively high labour productivity values and vice versa.

5.13. This suggests that there may be effects that are causing spatial dependence or spatial autocorrelation. Put another way, it is possible that plant level labour productivity levels are influenced by geographically close competitive firms. This may be capturing the types of spatial spillover effects identified above. On the other hand it may me that firms in a particular area benefit from some factor that itself displays strong and systematic differences across space – such as accessibility, labour supply or economic potential.

Figure 5.3: Labour productivity scatter plot



5.14. Figure 5.4 in similar fashion looks at the spatial distribution of levels of accessibility. It is noticeable that London, Birmingham, Manchester and other major English conurbations have particularly high accessibility values. High levels of accessibility also exist around much of the London commuter belt, between London and Brighton, across some areas from Birmingham, Sheffield, Leeds and Manchester, around Cardiff and along the M4 corridor as far as Bristol.

5.15. Figure 5.5 presents the scatter plot that corresponds to Figure 4. As would be expected this shows strong spatial autocorrelation in the data with accessible

areas being in very close proximity. The Moran's I statistic supports this proposition with a value of 0.5182, which is statistically significant at the 99% confidence level. It is pleasing to note that our accessibility index displays strong autocorrelation over space, and this provides greater confidence in the accessibility measure.

Figure 5.4: Standard deviation of accessibility

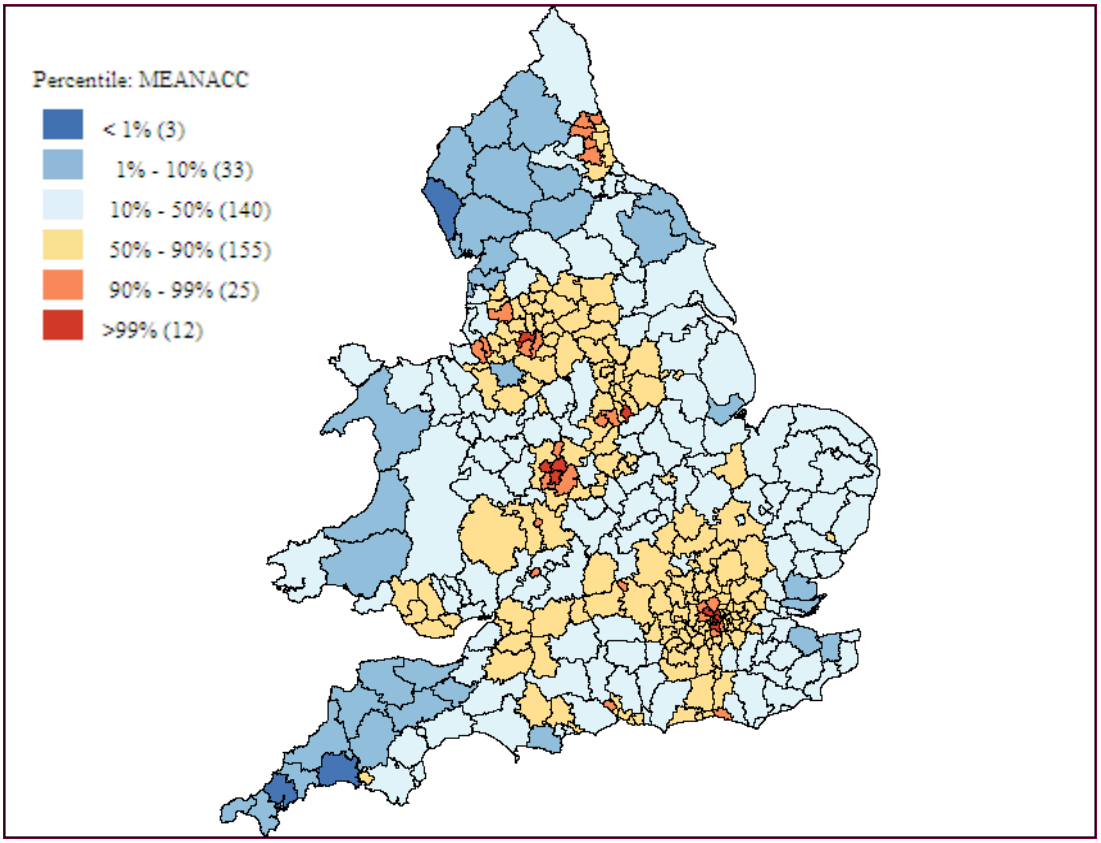


Figure 5.5: Accessibility scatter plot

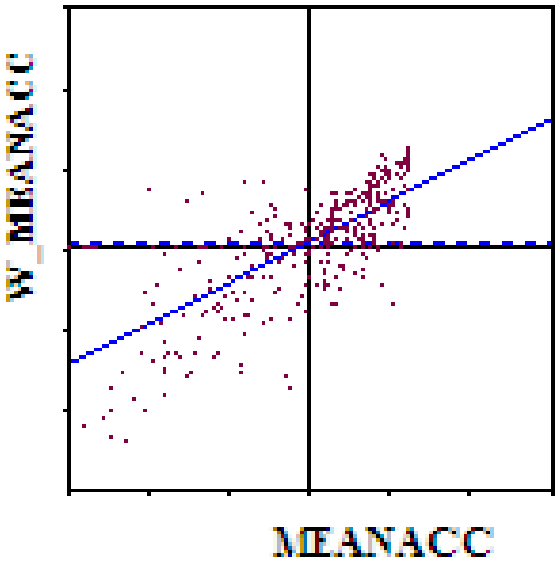
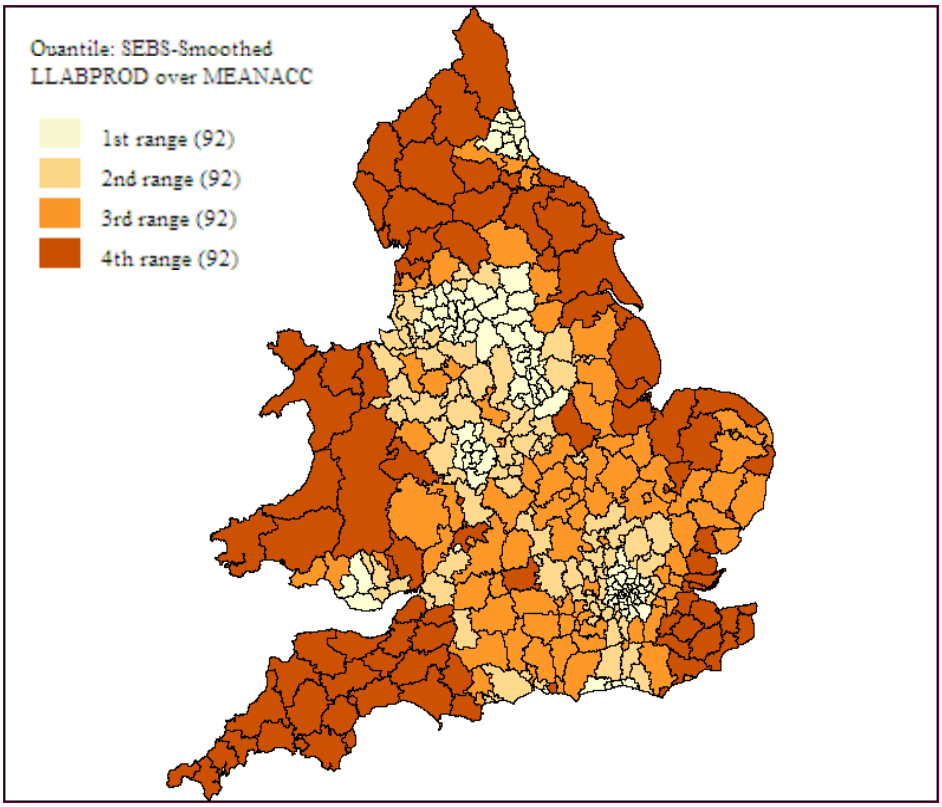


Figure 5.6: Spatially smoothed empirical Bayes quantile map of labour productivity over accessibility



5.16. Figure 5.6 presents a map of labour productivity weighted by accessibility which has been smoothed to take account of contiguous areas values – it takes account of small sample sizes linked to the number of contiguous areas. When Figure 5.6 is compared with Figure 5.4 it can be observed that high productivity districts are close together and that these are less common in Wales – the only higher productivity areas in Wales appear to be localised in the South East. This may be due to supply chains that are relatively concentrated geographically (although we see no particular reason for this being the case) or possibly the cost of crossing the Severn bridges which might act as a strong psychological as well as cost barrier that reduces competitive pressures from the English M4 corridor. It might also tend to reduce pressures for innovation and to reduce labour productivity levels.

Mapping of remaining explanatory variables

5.17. Of interest is whether the other explanatory variables also exhibit a degree of spatial autocorrelation and spatial dependence. This subsection presents such an

analysis of the part-time:full-time ratio, capital stock per worker and employment size.

5.18. Figure 5.7 and Figure 5.8 illustrate that there is little spatial autocorrelation in the part-time:full-time ratio; the slope of the regression line has a value of 0.0298, which has a statistical significance below the 90% level of confidence. The same can be concluded for capital stocks per worker (Figures 5.9 and 5.10) and employment (Figures 5.11 and 5.12).

Figure 5.7: Quantile map of part-time:full-time ratio

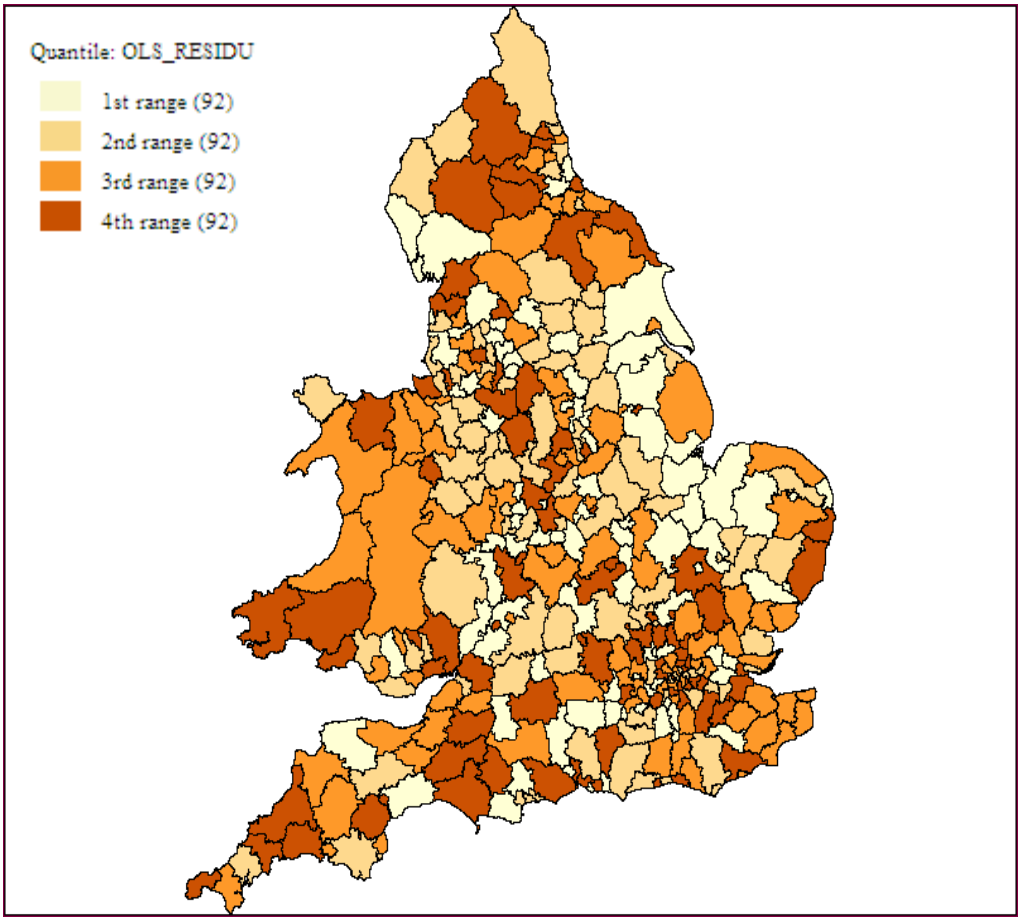


Figure 5.8: Scatter plot of part-time / full-time ratio (Moran's I = -0.0341)

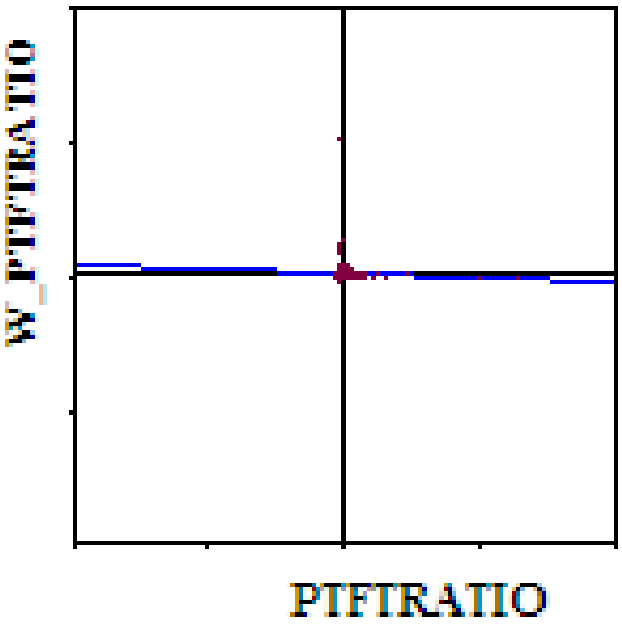


Figure 5.9: Quantile map of capital stock per worker

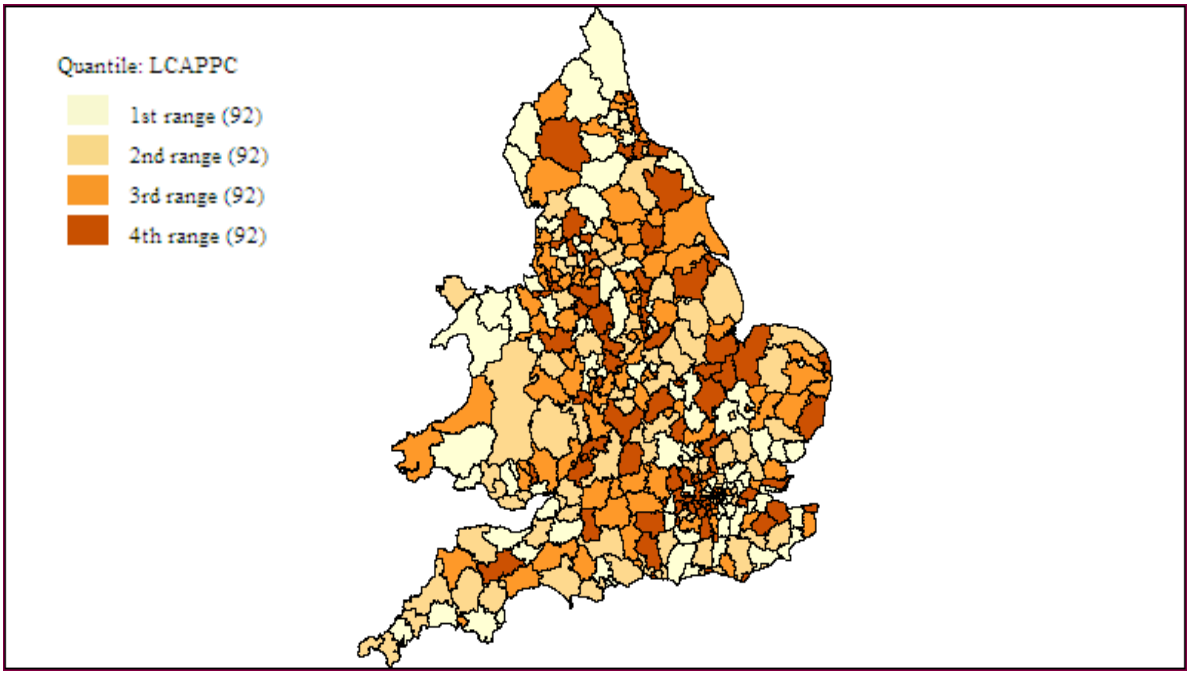


Figure 5.10: Scatter plot of capital stock per worker (Moran's I=0.0526)

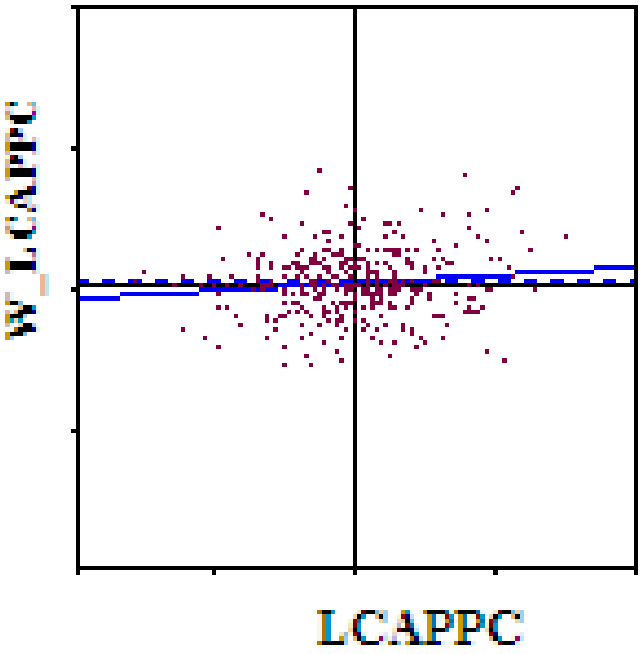


Figure 5.11: Quantile map of employment size of plants

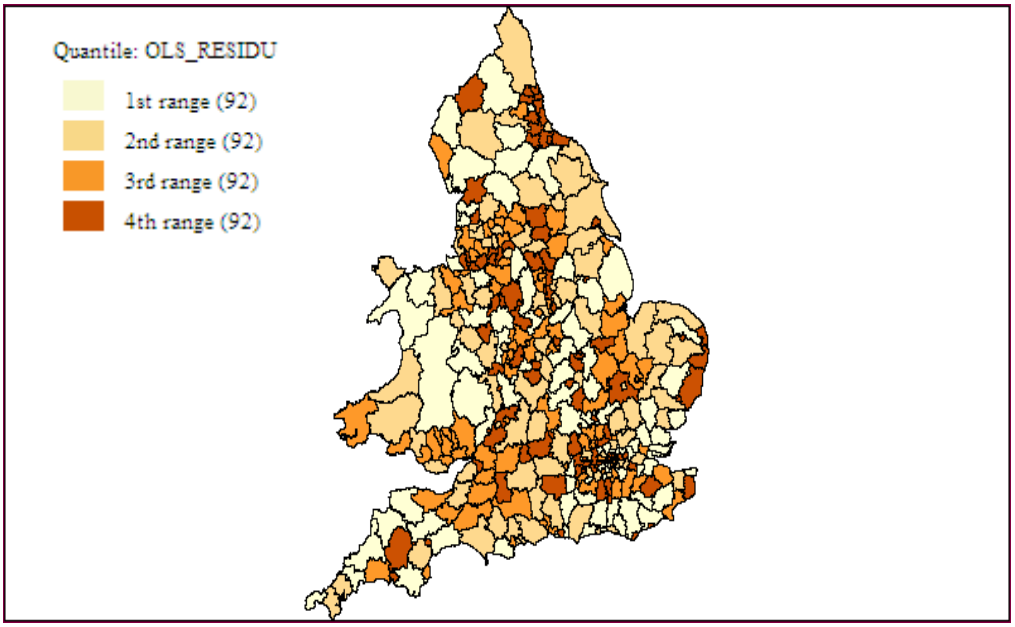
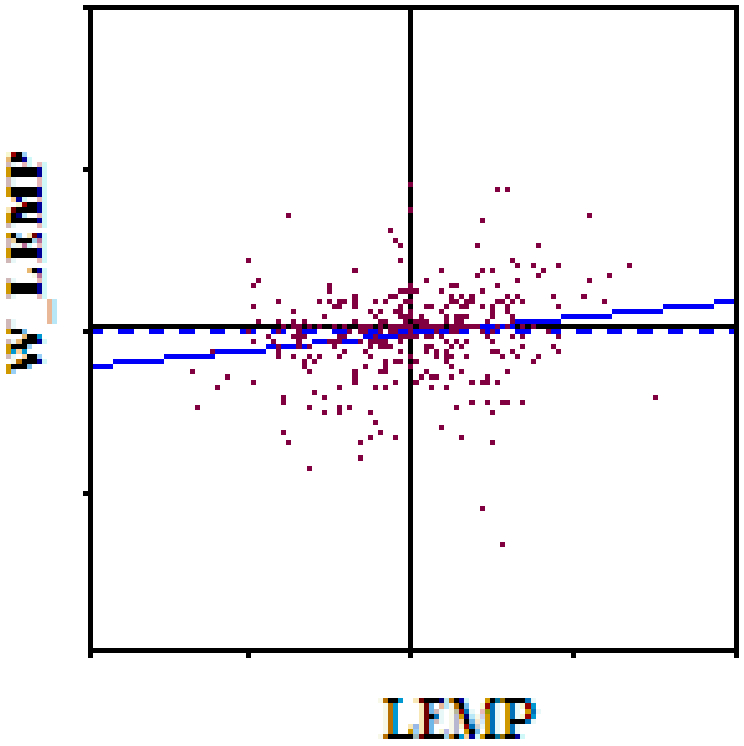


Figure 5.12: Quantile map of employment (Moran's I = 0.0991)



5.19. The evidence presented in Figures 5.7 – 5.12 indicate that there is very little spatial dependence in these extra explanatory variables. However we have seen strong spatial autocorrelation of labour productivity in Figures 5.1 – 5.3 and for accessibility in Figures 5.4 and 5.5. Given the presence of such spatial autocorrelation we now proceed to estimate spatial regressions.

Spatial Regressions

5.20. Spatial regression can be used to investigate the influence of spatially evolving relationships. Two types of regression models are typically employed: the spatial error model and the spatial lag model. If there were strong theoretical reasoning to believe that the errors of an OLS regression would be spatially autocorrelated then the appropriate technique is to estimate a spatial error model, which is commonly specified as follows:

$$y = X\beta + u \quad (1)$$

where y represents the dependent variable, X represents the independent variables and the constant term, β is the regression parameters which are to be estimated and u is the error term. This error term is presumed to have a covariance structure as given by:

$$u = \rho Wu + \varepsilon \quad (2)$$

where ρ is a spatial lag parameter to be estimated, W is a weights matrix defined by the area's neighbourhood such that Wu captures the spatial lags of the model's disturbance term, u, and ε is the independently distributed error term. Elements w_{ij} from the W matrix capture the influence on area i of its neighbours, j. Under this specification spatial autocorrelation in the dependent variable is the result of exogenous influences captured in the error term and not directly from the explanatory variables. This typically occurs because the list of explanatory variables does not contain a variable which captures the spatial autocorrelation that appears in the dependent variable. As shown in the previous sections, the only spatially evolving explanatory variable appears to be accessibility.

5.21. It is possible to estimate a model which explicitly captures spatial autocorrelation. This type of model captures spatial autocorrelation as an explanatory variable in the form of spatial lag function.

$$y = \lambda Wy + X\beta + u \quad (3)$$

In this formulation, Wy captures the spatially-weighted average of the dependent variable for an area's neighbouring locations and λ is the spatial lag parameter to be estimated.

5.22. The first step in constructing a spatial equation is to attempt to identify where the spatial autocorrelation is entering the relationships. There are two simple ways where this can occur. The first is through a *spatial lagging* of the labour productivity and the second is through the autocorrelation present in the *error* terms; to identify whether either is the case we first need to estimate a simple ordinary least squares regression and determine whether we need to employ a *spatial lag* or a *spatial error* model. The fact that the employment term is not statistically significant suggests that there are constant returns to scale.

5.23. Table 5.1 presents this OLS model. These results support many of the results that were based on plant level data, rather than on local authority aggregate level data; the part-time:full time ratio, capital stock per worker and accessibility all influence average labour productivity levels.

5.24. Table 5.1 shows that the model passes all of the specification tests: neither multicollinearity nor heteroskedasticity appear to be strongly affecting the results. Of particular interest however is the Moran's I statistic, which indicates that there is spatial autocorrelation present in the errors.

5.25. The Lagrange multiplier and Robust LM tests are all highly statistically significant suggesting that spatial models should be employed in this econometric modelling process. However the error values presented in the final two rows of Table 5.1 are substantially larger than the lag values. This again indicates that we should be using a spatial error model in our analysis.

Table 5.1: OLS regression

	OLS
n	368
Constant	1.856 (0.113)***
Employment	-0.041 (0.036)
Pt / ft ratio	-0.015 (0.007)**
Capital per worker	0.377 (0.036)***
Llunit	0.105 (0.059)
Mean accessibility	0.031 (0.005)***
Breusch-Pagan test for heteroskedasticity	6.999
Multicollinearity condition number	33.959
Log likelihood	88.352
R^2	0.360
F-statistic	40.720***
Moran's I (errors)	6.193***
Lagrange Multiplier (lag)	9.065***
Robust LM (lag)	6.075**
Lagrange Multiplier (errors)	24.947***
Robust LM (errors)	20.957***

Note: Queen contiguity matrices employed throughout

5.26. Figure 5.13 presents the standard deviation of the predicted values based on this OLS model. These should be compared with Figure 5.2 which sets out the actual values. The first thing to note is that many of the colours are correct: the model is predicting many of the low productivity values in Wales and the South West and many of the high values in the London area and around other large conurbations. However there are a number of areas that are unsatisfactory, such as Pembroke, Ceredigion and North Devon. Similar issues arise when we compare the quantile maps of Figure 5.14 with Figure 5.1.

Figure 5.13: Standard deviation of predicted values

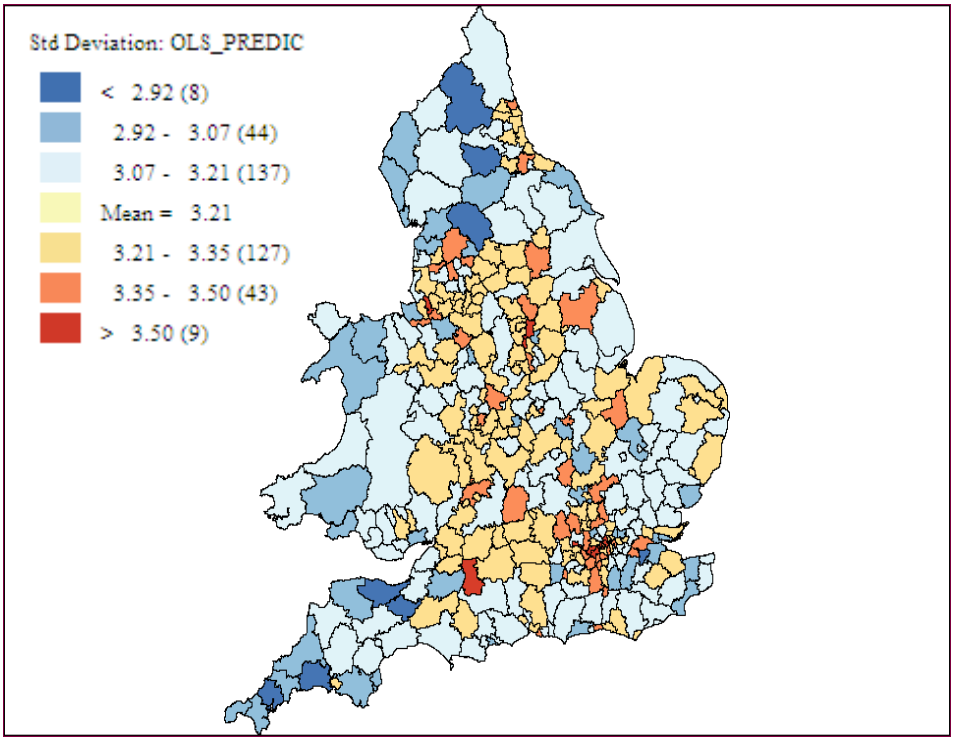
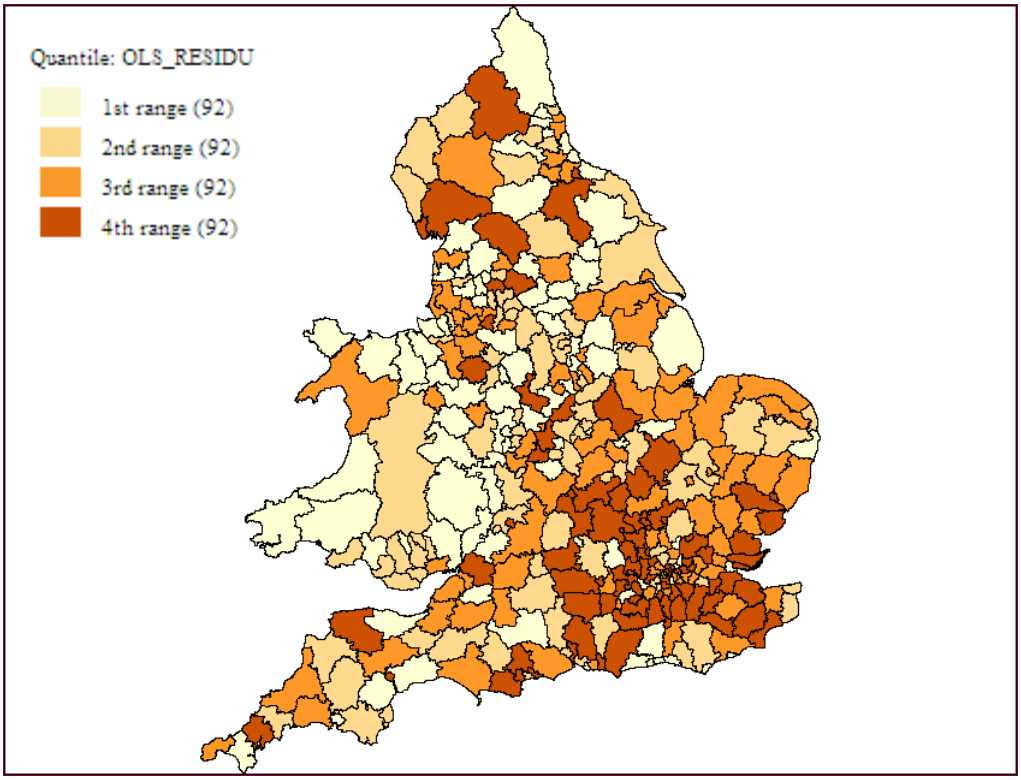


Figure 5.14: Quantile map of residuals



5.27. Given the diagnostic test results at the bottom of Table 5.1 we proceed to estimate a spatial error model. These results are presented in Table 5.2. This spatial error regression model takes into account the error values in the areas contiguous to each area.

Table 5.2 again supports the importance of the part-time:full-time worker ratio, capital stocks per worker and accessibility as being the statistically significant drivers of area-based labour productivity values after plants have been clustered into local authority areas. Of importance is the likelihood ratio test for spatial error dependence for the weight matrix: this indicates that taking into account the spatial error values of contiguous areas significantly improves the econometric model. This is also reflected in a higher R^2 and log likelihood values.

Table 5.2: Spatial error regression results

	Spatial error
N	368
Constant	1.910 (0.111)***
Employment	0.014 (0.028)
Pt / ft worker ratio	-0.010 (0.006)*
Capital per worker	0.330 (0.032)***
Llunit	-0.019 (0.056)
Mean accessibility	0.020 (0.007)***
Lagged coefficient (Lambda)	0.763 (0.035)***
Breusch-Pagan test for heteroskedasticity	4.256
Likelihood ratio test for spatial error dependence for weight matrix	36.829***
Log likelihood	106.767
R^2	0.414

Notes: Queen contiguity matrices employed throughout

5.28. The model can thus predict the observations for labour productivity with considerable success and these are presented in Figure 5.16. The spatial pattern depicted in Figure 5.15 is much closer to that presented in Figure 5.22. These results are supported by the pattern of the residuals in Figure 5.16. There now appears to be little spatial relationship in the residuals.

Figure 5.15: Spatial error model predictions

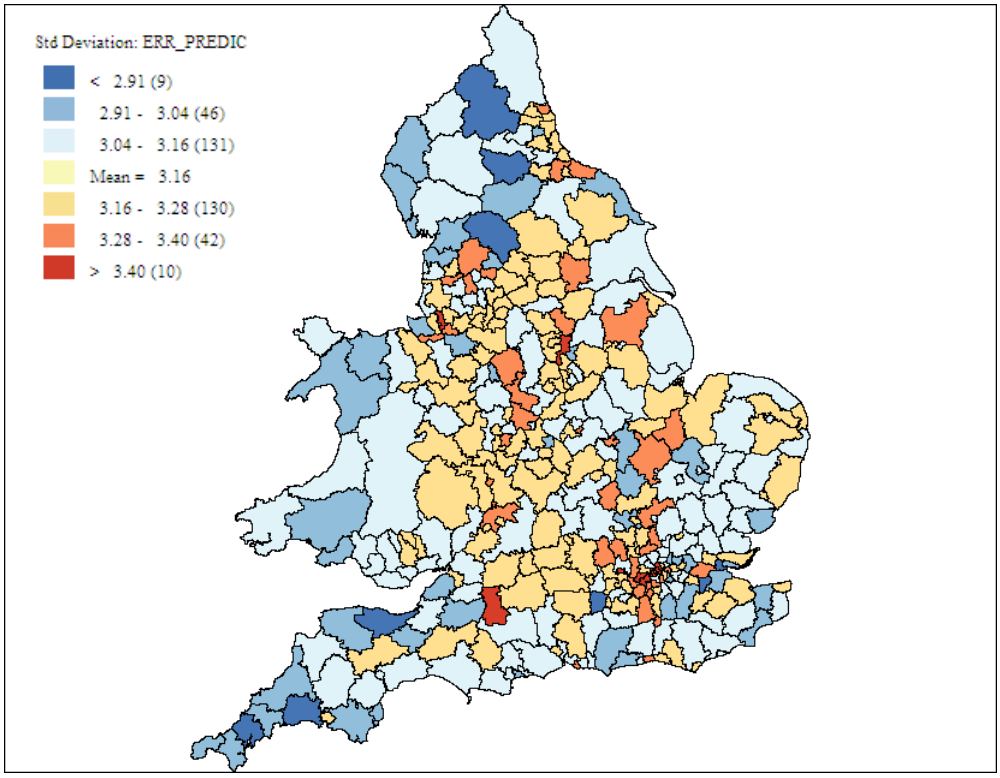
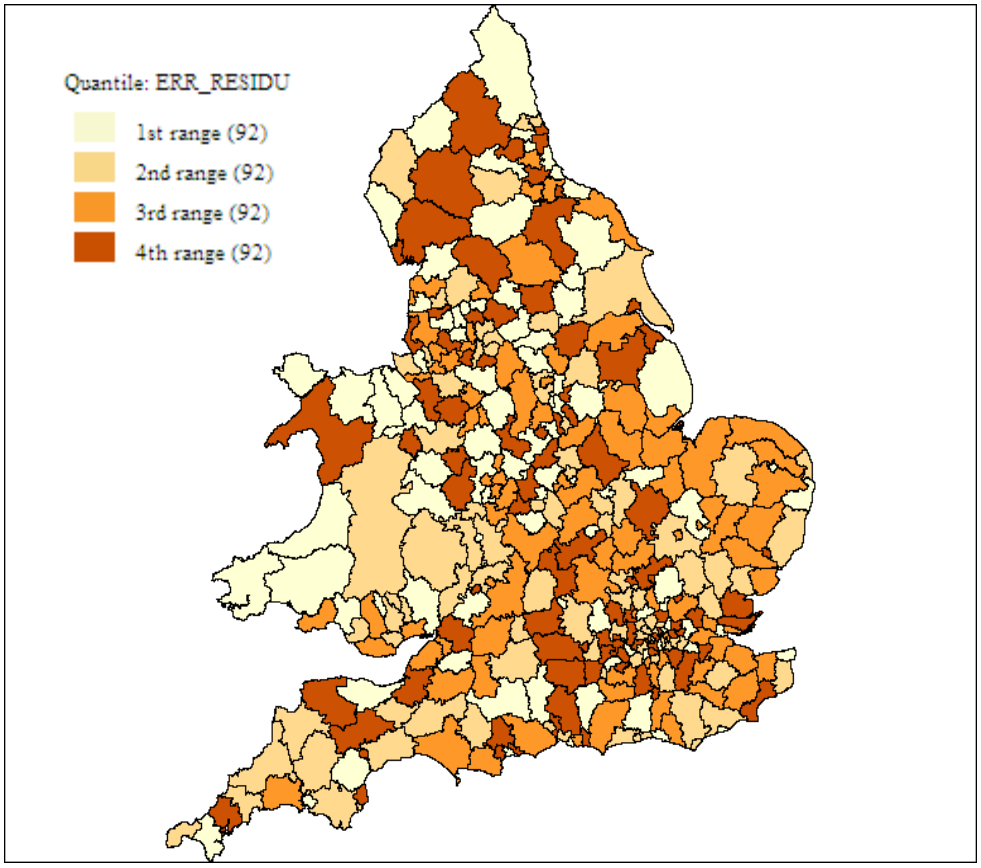


Figure 5.16: Residuals of the spatial error model



6. VIRTUAL PERIPHERALITY IN WALES – AN EXPLORATION

6.1. The earlier review (section two) distinguished between conventional accounts of peripherality grounded in space and distance and the idea of aspatial or virtual peripherality. This section presents a brief exploration of virtual peripherality in the context of Wales. The literature discussed above concentrates predominantly on computer internet access as the principal dimension of virtual connectivity. There is a case that 3G mobile phone service provision and digital media reception are also important. In the case of the latter, the relevance to business efficiency and growth may not be particularly compelling. However restricted access to digital media may well have bear negatively on the attraction of high level skills into a peripheral area and may influence inward investment.

6.2. Following Copus and Macleod, virtual peripherality has two elements – infrastructure provision and take-up. Data on access to ICT infrastructure from providers is unreliable. Even in the case of Broadband provision where it is claimed that Wales has near total coverage, there is considerable variation in speed. With mobile phone and digital media, anecdotal evidence suggests that the coverage claimed by providers is optimistic and many peripheral areas suffer from an unsatisfactory service. To unpick these complexities of access is beyond the scope of this report.

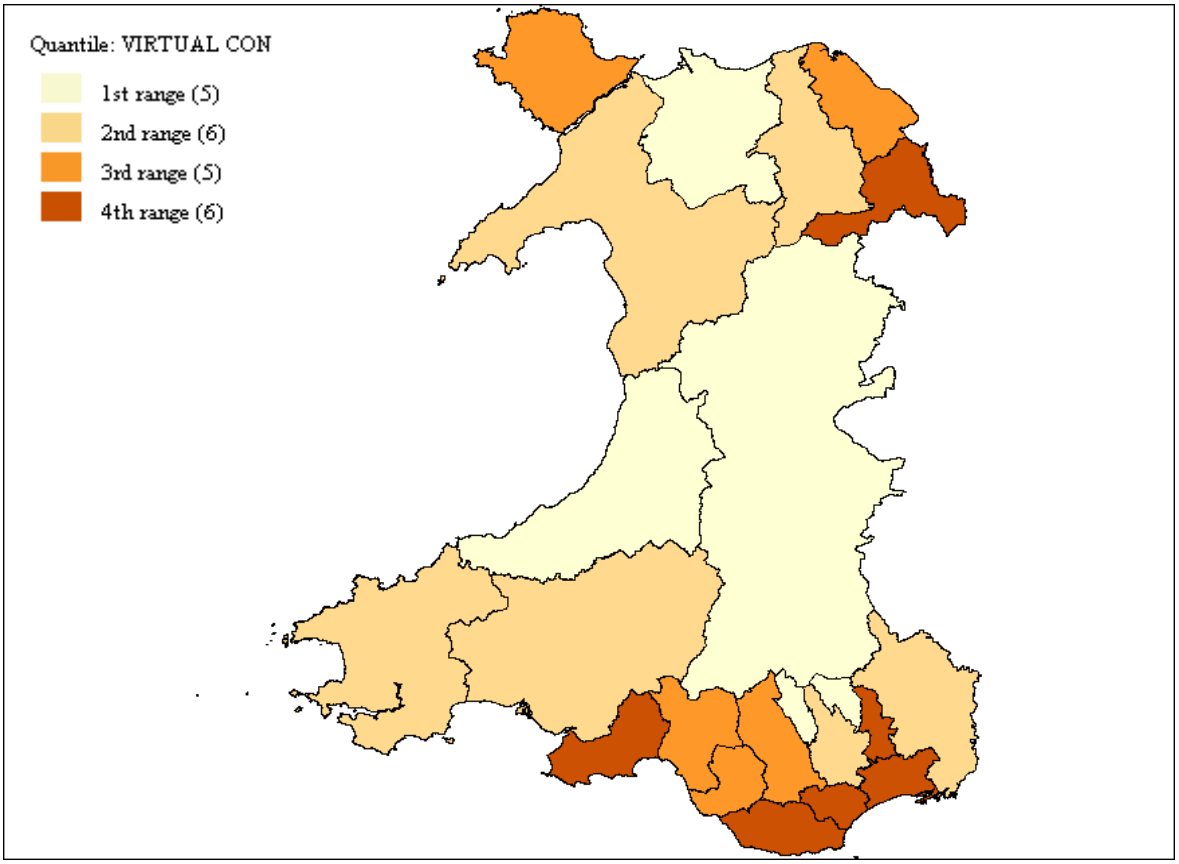
6.3. Recent spatial data on business internet use is not available. However we were provided with a dataset on household ICT use by the Economic Advice Division of the Office of the First Minister. The data was broken down by LA area and thus can be used as some indication of ICT coverage. The categories of usage were:

- Having a PC at home

- A PC with internet at home
- Broadband internet access
- Multichannel TV
- Digital radio
- Mobile phone service
- 3G mobile phone service
- Mobile phone

6.4. To obtain some indicator of the reach of more advanced forms of ICT, an index of virtual connectivity was constructed by averaging the proportion of households with Broadband, Multichannel TV, Digital Radio and 3G mobile phone for each area. The overall pattern of usage for Wales given by this index is shown in Figure 6.1 below

Figure 6.1

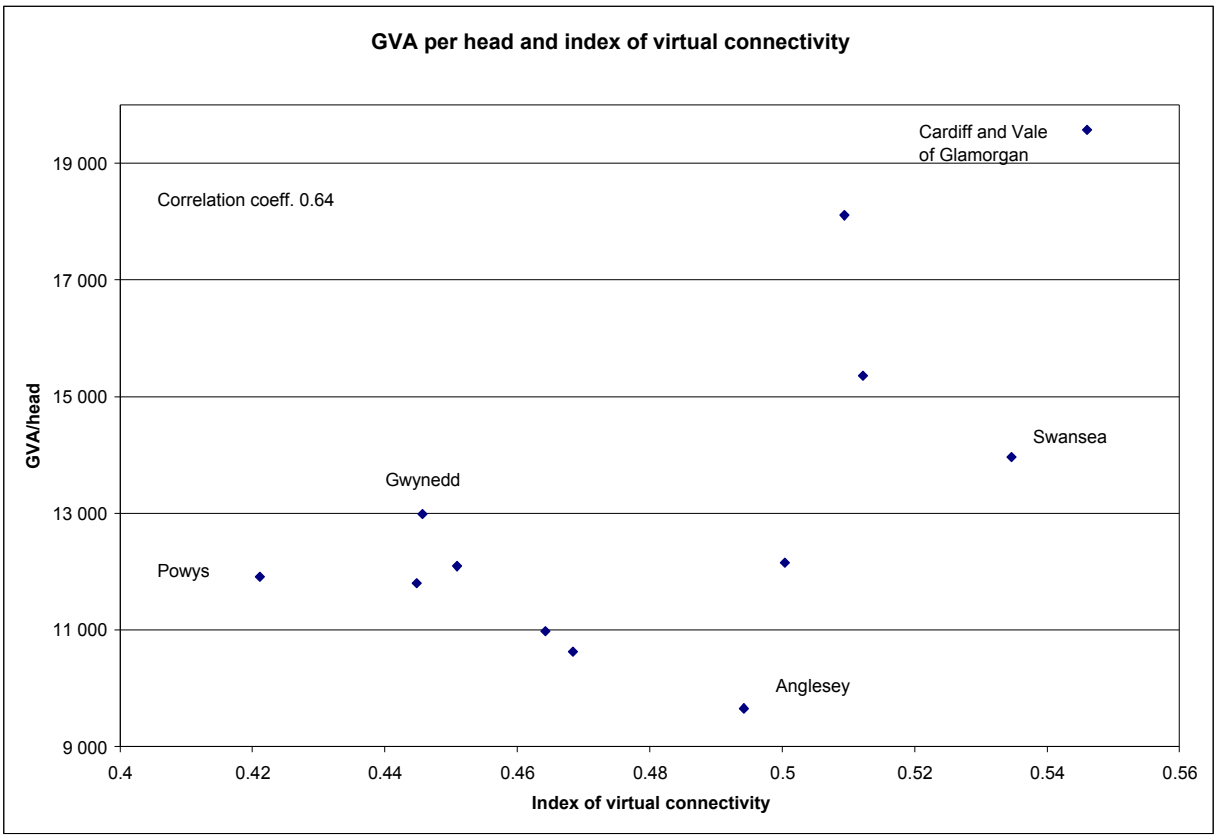


Source: authors calculations from data supplied by DoFM-EAD

6.5. Inspection of the map above does not indicate a clear pattern of virtual connectivity compensating for spatial peripherality, except perhaps for Anglesey and to some extent for Gwynedd, Pembrokeshire, Carmarthenshire and Swansea.

6.6. Although the virtual connectivity index is based on household data, to the extent that this might be a proxy for coverage and thus the potential for business connectivity. Thus some relationship with productivity through encouraging high level skills migration and inward investment. Figure 6.2 examines the relationship between aggregate productivity at the NUTS 3 area level from 2005 ONS data and the connectivity index.

Figure 6.2

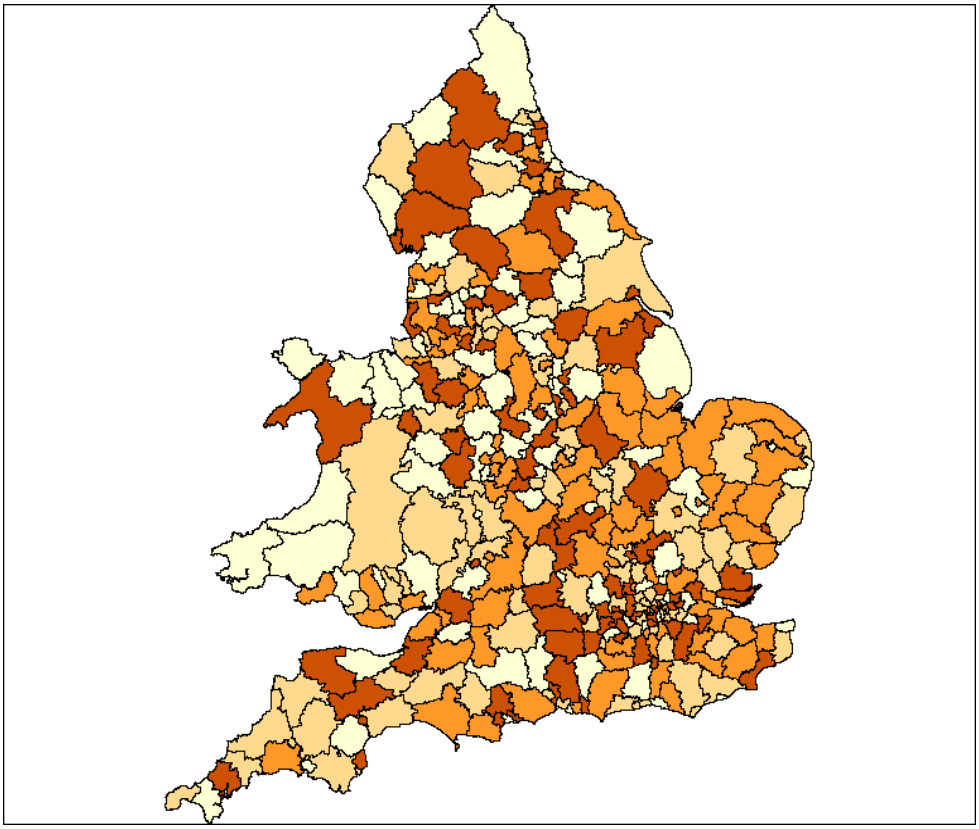


Source: authors calculations from data supplied by DoFM-EAD and ONS

6.7. Although there is a moderate positive correlation between virtual connectivity and productivity, the direction of causation is highly questionable. It may well be that the strong association between productivity measured by GVA per head and earnings is driving the relationship: the higher household incomes in an area, the greater the expenditure on ICT products and services. Further, 2007 virtual connectivity data is being compared with 2005 productivity data. This may appear to defeat an attempt to show a causation from virtual connectivity (2007) to productivity (2005) from the outset. Nevertheless, it is highly likely that virtual connectivity in 2005 would be highly correlated with virtual connectivity in 2007. Indeed the Beaufort Omnibus time series data for Wales NUTS 2 areas gives strong evidence for this assumption.

6.8. Finally, Figure 6.3 shows the unexplained variation in productivity after taking into account firm level factors, sector, physical accessibility and spatial spillover effects. Comparison with Figure 6.1 above shows there is no recognisable similarity in the pattern of areas of Wales. In other words, in does not appear that the household based virtual connectivity index complements spatial peripherality in explaining variations in productivity across Wales.

Figure 6.3: Residuals of the spatial error model



6.9. In conclusion, while we have not been able to add to the explanation of productivity differentials in Wales by exploring virtual peripherality, this is essentially due to the lack of appropriate data. The literature suggests that virtual connectivity is an important driver of business growth in other areas of the UK and EU. There is thus a strong case for further research to explore the impact of virtual peripherality on businesses in Wales and to examine the extent to which virtual connectivity can help to overcome the handicap of spatial peripherality.

7. Conclusions and policy implications

7.1. The analysis presented here has emphasised the importance of accessibility and peripherality as having a significant impact on productivity, once other factors have been taken into account. This is the case in terms of spatial differences in productivity across Wales and England as a whole. It is also the case at a more detailed level within Wales.

7.2. The study looked at the impacts of a range of different measures of accessibility and productivity. Accessibility refers in a technical sense to a measure of accessibility based on travel time by road to local towns and cities.[18] Peripherality refers in a technical sense to a broader-based index which combines the distance, via the road network from any one local authority area to all others in England and Wales, weighted by the mass or size of each place measured in terms of population.

7.3. A variety of different indicators constructed from these basic measures were found to be associated to a greater or lesser degree with productivity. These proved more effective in terms of explaining productivity differentials than the somewhat crude measures employed in earlier studies.

7.4. In practice, the 'index of accessibility' based on travel time to towns and cities proved to be somewhat better at explaining such differences than the alternatives – this may suggest that it is more localised differences that matter rather than economic potential at a much broader geographical scale.

7.5. A possible corollorary is that, with the exception of Cardiff and the eastern end of the M4 corridor, Wales as a whole is peripheral compared with England such that the more broadly defined index of peripherality is less effective at picking up differences between places, particularly those further away from the economic centre of gravity of England and Wales.

7.6. Analysis of productivity differentials within Wales points to the sharp differences between South East Wales (and the M4 Corridor in particular) on the one hand, and the West Wales in particular. The same is true comparing North East Wales and adjacent areas of England with Central and North West Wales. These would seem to reflect to a significant extent the sharp differences in accessibility between these sub-regions evident from the detailed mapping of this index.

Improving transport infrastructure

7.7. The benefits to more peripheral regions of physical transport infrastructure investment, such as improved rail or road links is at one level an obvious response to issues of accessibility and peripherality. The benefits are not always, however, as self-evident as they may seem. Investment frequently improves links to and reinforces the relative advantage of existing urban areas. It may lead to local markets being supplied by more productive businesses in less peripheral areas, benefiting from scale economies, who are able to supply local markets more efficiently thanks to increased access. It can also expose businesses in more peripheral regions, previously protected, to increased

[18] Cities within 2 hours, towns within 0.5 hours

competition – which may be beneficial if this prompts innovation and improved productivity. It may however lead to prices being driven down locally and can threaten the viability of local businesses.

7.8. Others have pointed out that whilst good transport infrastructure is a necessary rather than sufficient condition for economic competitiveness there are few examples of successful economic development in places that lack such infrastructure. There may be scale effects as well and differences related to degrees of remoteness. In the case of Wales, for example, the benefits of the old and second Severn crossings in terms of the development of the Welsh M4 Corridor up to and including Cardiff would seem to be clear. We do not have specific evidence but the benefits of extending the M4 further west may have to a significant extent accrued to Cardiff and south east Wales as well as to places further to the west. The same may be true of improved access to the valleys with benefits accruing in part to the M4 corridor as well as more remote locations – and possibly impacting differently on different sectors.

Sector differentiation

7.9. Different types of economic activity will be impacted on by poor accessibility and peripherality in different ways. It may be possible to identify sectors or sub-sectors, or types of activity differentiated in some alternative way, at to promote and support the development of these in more remote areas. The type of statistical analysis presented here is relatively coarse-grained in terms of sector differences and issues of sample size and confidentiality would preclude more fine-grained analysis.

7.10. There are some broad indications including, for example, that the hotel and catering sector within Wales suffers no adverse effects from poor accessibility – in contrast to other broadly-defined sectors. This may reflect lack of competition from other businesses operating in more accessible locations – which by definition do not represent an alternative to customers wishing to use such facilities in particular locations within Wales for example. It may also reflect the fact that attributes associated with remoteness including scenic values and recreational demand may well be positive factors in many cases.

7.11. Accessibility, proximity to larger agglomerations of economic activity and locations with high levels of economic potential confer considerable benefits in terms of competitiveness and productivity. Turning this on its head, support for and promotion of types of economic activities where the factors underlying these benefits are less relevant may present opportunities. One would be seeking to identify activities where, for example, physical access to concentrations of high market demand, proximity to specialist suppliers and business services and localised interaction with other businesses were largely irrelevant. This might include small businesses where rural quality of life is seen a positive locational factor including potentially creative industries or virtual business services that are less reliant on frequent face-to-fact contact.

Focus on more peripheral areas with the greatest potential

7.12. It also needs to be recognised that rural areas with possible comparable levels of peripherality as measured by indices, vary greatly in terms of their attractiveness to more highly skilled and qualified ‘knowledge workers’ and entrepreneurs –

this can be seen from the distribution across rural areas of the proportion of the working-age population qualified to degree level or above. This suggests the possible benefits of targeting investment and policy intervention on areas with a high concentration of such populations.

Aggregation of supply chains or market potential

7.13. Many suppliers in more remote areas are relatively small and relatively isolated one from another. Any one supplier of goods or services is unlikely to be able to make a significant impact in terms of establishing contacts, marketing or ensuring significant supply volumes to volume markets in more distant markets.

7.14. There are examples, however, of rural, quality food producers, which have been able to combine forces and to successfully market under a joint brand name a range and volume of goods that can be supplied to major retailers and supermarket chains.[19] This represents a form of aggregation of local supply chains and market potential in a way which overcomes peripherality and fragmentation.

Capitalising on intrinsic value

7.15. It may be possible to promote and support activities which derive value and market potential specifically from the (more remote) locations and the attributes of these products or services that derive intrinsic value from their location that can offset what are otherwise the disadvantages of poor accessibility and peripherality. The branding and supply of local products in the food and drink sector is a well-tried example. This can also be combined with the aggregation of supply chains and marketing as outlined in the previous paragraph.

7.16. Local accommodation and visitor attraction is another obvious and well-tried example where it is the intrinsic attractions of a local area that provide the basis for competitive strength. It is clear, however, that in a very competitive overall market, the quality of visitor attractions, effective aggregation and marketing of what is on offer and the efficiency of the supply chain including its insertion into e-marketing and sales media are crucial.

Promoting virtual accessibility and agglomeration

7.17. Physical remoteness and geographical dispersal have typically been seen as the key elements of poor accessibility and peripherality. It may, however, be possible to develop initiatives that counter the negative impacts of 'adverse geography' by electronic means. This would include the promotion of and support for e-marketing and e-sales and support, including both physical goods but also a variety of service functions where order and supply can be conducted electronically without the need for travel of face to face contact. This would require appropriate technical capabilities – and this is an aspect of 'virtual peripherality' as discussed earlier. It would also require greater inputs in terms of promotion, training and support services for businesses that might benefit.

[19] An example is Mey Selections, brand name of North Highlands Products Ltd, formed by farmers and other producers in Caithness to supply and market a range of products now distributed on-line, through independent retailers and through Sainsbury supermarkets.

7.18. Clustering in physical space has been much emphasised in recent studies emphasising the role of face to face contact and easy access in promoting trust, collaboration, knowledge exchange, and knowledge generation. It is seen as reinforcing market relations between buyers and suppliers, reinforcing supply chains, creating economies of scale and scope through networking and joint activities and stimulating knowledge generation and innovation. It may increasingly be possible, however, to replicate some at least of this in a variety of forms through the promotion of clustering, 'business networking' (emulating the growth of social networking sites) and density of contacts in virtual or electronic space.

7.19. Restricted local markets might be expanded by web-based marketing and sales. Lack of access to specialist suppliers and services might be eased by web-based searches, networks and purchasing. The limited scope of local labour markets might be expanded through internet job search and recruitment – although residential location and access remain constraints for potential recruits.

7.20. Lack of face to face contact and networking might therefore be offset, partially at least, by on-line contact, information pooling and the creation of targeted networks or virtual business and professional communities – and might lead to subsequent face to face contact. The creation of such virtual agglomerations or clusters might be targeted on particular industrial sectors or activities and tailored to existing strengths in particular localities, building and extending on what is already there.

Exploiting economic mass

7.21. Cardiff is the one sub-region in Wales with above average levels of productivity in the overall context of England and Wales. This reflects a combination of factors which determine levels of economic performance including sectoral composition, skill levels, capital investment and other factors. Significantly however, it is the only part of Wales that enjoys levels of accessibility or 'centrality' comparable to the main urban areas of England and Wales. This apart, as noted earlier, the whole of Wales is peripheral to the economic mass of the English spatial economy.

7.22. There are clearly issues of spatial equity but this provides a potentially strong argument for concentrating investment where it is likely to generate the highest returns in terms of productivity. This might be linked to strategies to further improve local accessibility in order to spread the positive benefits over a wider area.

7.23. Similar arguments might apply to Newport and Swansea which also benefit from the M4 corridor effect but represent smaller and in Swansea's case more remote clusters than Cardiff itself, and also to Flintshire and Wrexham in the North East.

National infrastructure projects

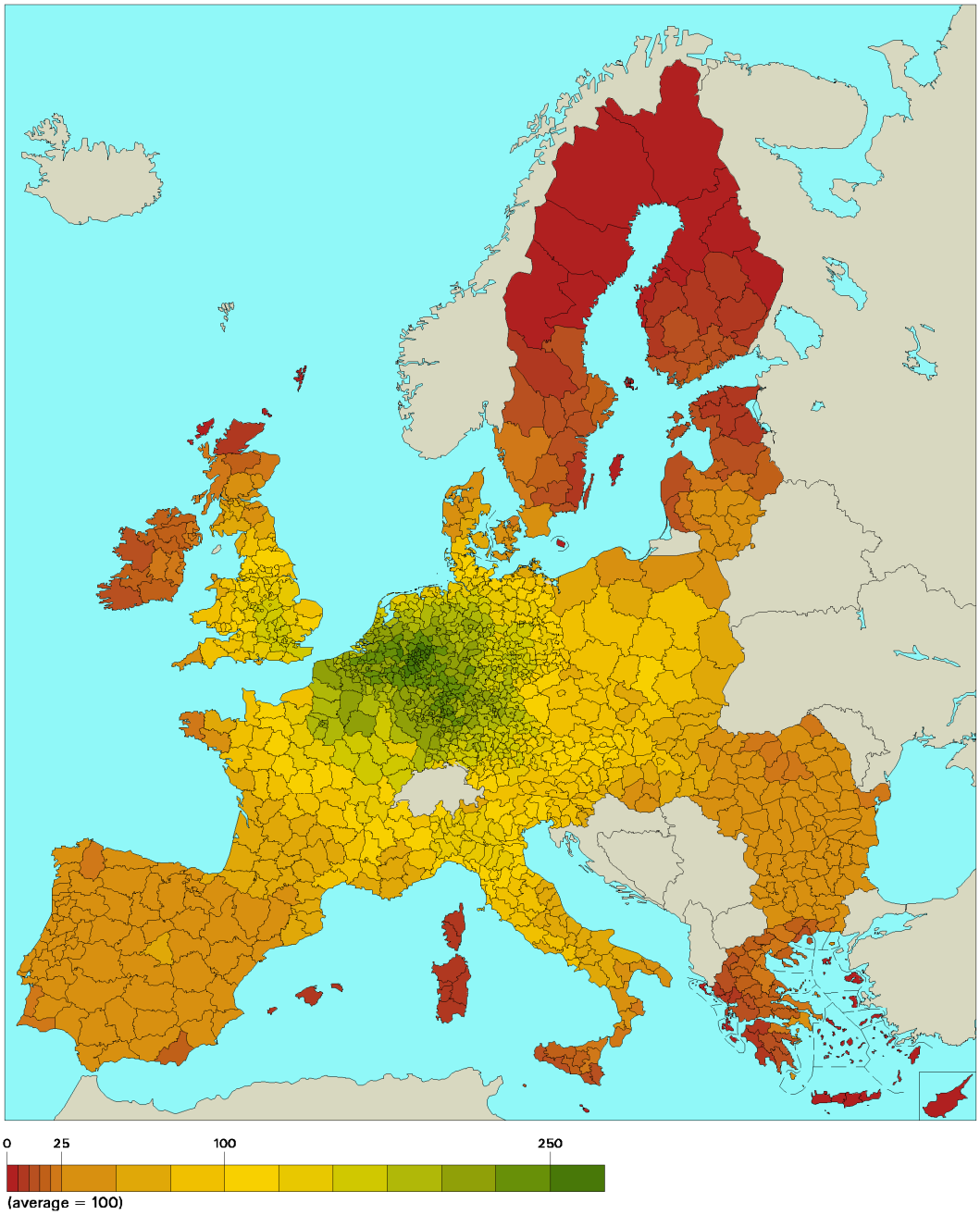
7.24. As indicated, levels of accessibility and productivity in Cardiff are comparable with those in other significant urban centres across England. The Second Severn Crossing in particular has clearly done much to improve accessibility and counter peripherality. By UK standards, however, it is nevertheless relatively limited in terms of economic mass certainly compared with London

and the SE but also Birmingham and the midlands, or Manchester/Liverpool. And much of the rest of Wales can be considered peripheral in relation to most of England – contributing to the fact that productivity across most of Wales is below that across much of England.

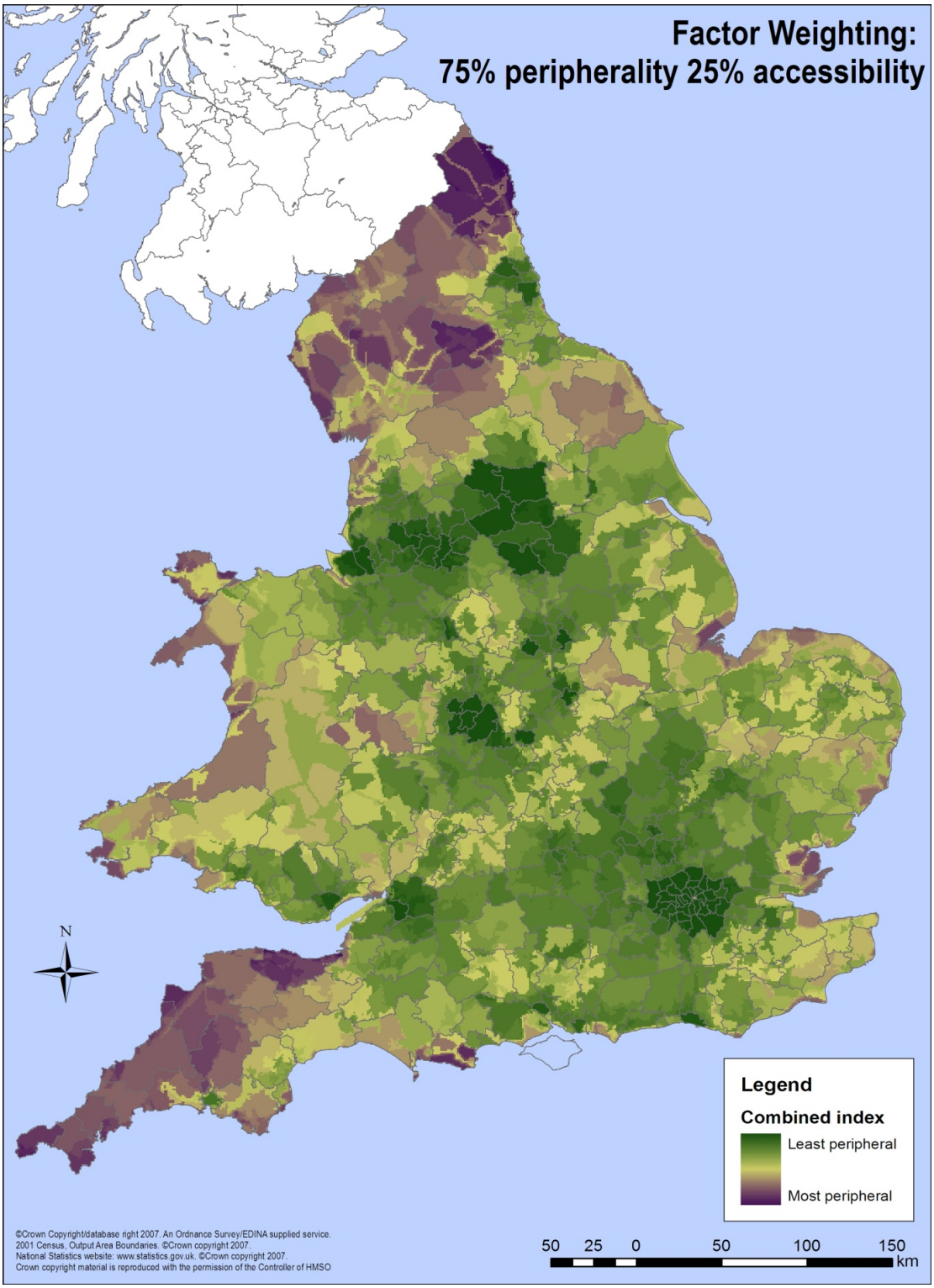
7.25. This suggests that there are still benefits to be secured by addressing the barriers presented by the Severn Crossings and in particular the real and perceived effects of congestion and disruption on the M4 and M5. High speed rail links to London allowing business to be conducted in the context of a day-trip are also likely to remain significant – providing considerable potential benefits compared with car-travel.

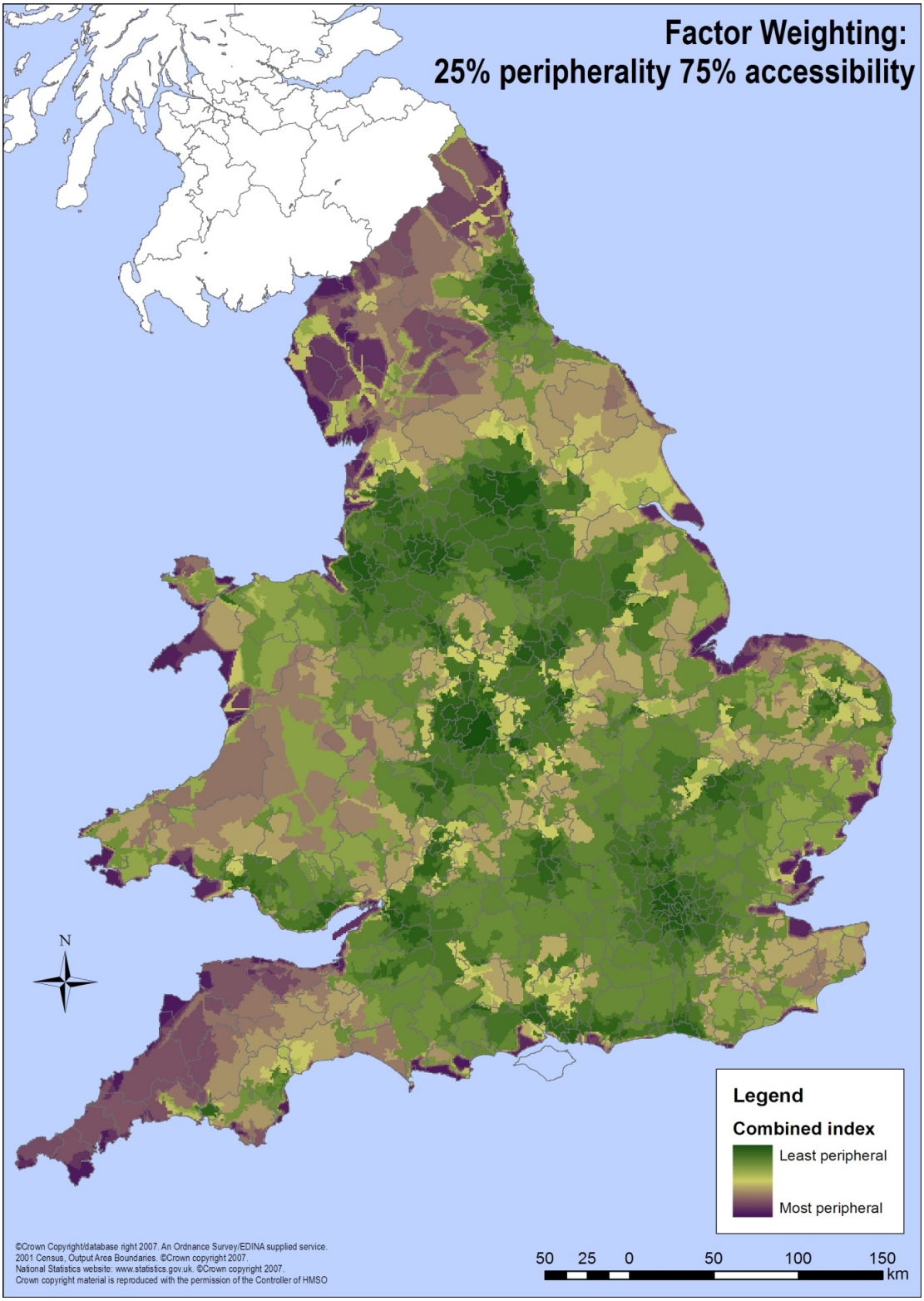
7.26. In the north east as well the dense motorway network extending west from Manchester are far as Chester and the Wirrall contrasts with provision over the border into Wales – albeit there is now good quality dual-carriageway access across north Wales. North-South links within Wales are of course very poor for topographical reasons and there is little integration between the M4 Corridor and north-east Wales. Any additional infrastructure investment would represent major projects to be addressed at a national level and assessed against other priorities.

Appendix One: European Peripherality Index (Schulmann and Talaat, 2002)



Appendix Two: the spatial distribution of alternative combinations of peripherality and accessibility, England and Wales




Factor Weighting:
25% peripherality 75% accessibility
N
Legend
Combined index
Least peripheral
Most peripheral
50 25 0 50 100 150
km
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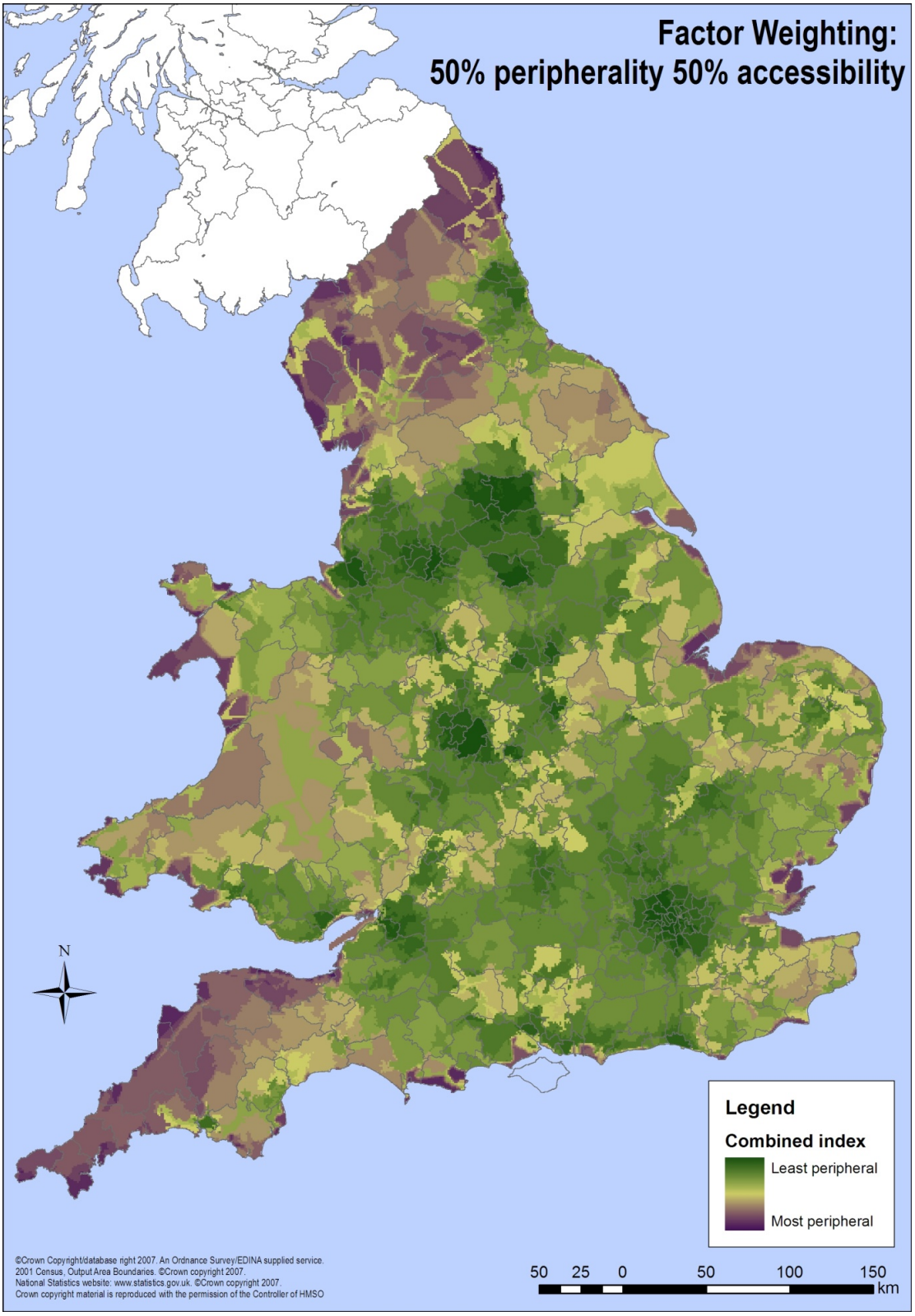
Factor Weighting:
50% peripherality 50% accessibility
N
Legend
Combined index
Least peripheral
Most peripheral
50 25 0 50 100 150
km
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