University of the West of England, Bristol

Report update:

Understanding productivity variations between Wales and England

Report to the Government of Wales

University of the West of England, Bristol

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Introduction

1. This is an update of a report presented to the Government of Wales in 2006 in which we sought to identify the effect of inaccessibility on productivity across Wales. Our focus was specifically on travel time / distance using the road network from any District to London and to the four next largest conurbations in Britain: Birmingham, Manchester, Leeds and Glasgow. Our 2006 report used 2003 data from the Annual Respondents Database of firms, which has since reincarnated as the Annual Business Survey (ABS).

2. This report presents comparable regression estimates of the effect of accessibility on productivity using statistical analysis of the ABS[1] business-level database. Data from this source relates to 2012, which is the latest year for which information is available including the capital stock estimates. The ABS data set contains information on all firms with greater than 250 employees and a structured sample of firms with fewer than 250 workers; this means that the sample of firms in this analysis will be different to those analysed in the 2006 report. Small firms are also likely to be underrepresented.

3. Productivity is widely used as a measure of economic prosperity and is argued to be a key determinant of living standards. It measures value added for goods and services produced, expressed in a standardised format. However, there are different ways of estimating productivity. Gross Value Added (GVA) per head is the commonly-used 'headline' measure. It expresses the volume of GVA relative to the population in a given geographical area but overstates productivity in areas with a significant degree of inward commuting – typically larger urban areas – compared to other areas.

4. Business level data – as used in this study – makes it possible to relate output at the level of individual business units to the size of their workforce. This makes it possible to measure productivity at the level of individual business units, and this means that differences in productivity between Wales and other countries and regions are not affected by differences in the size of working populations or commuting patterns, as is the case with commonly-used measures of output per head of population.

5. Business level productivity can also be related to a wide variety of other characteristics at the level of the individual business unit and to characteristics of the local area, such as population density or levels of qualifications. These can then be aggregated up to a variety of spatial units. This type of analysis has considerable advantages over published ONS data based on spatial aggregates.

6. Key 'productivity drivers' used to explain differences in productivity in this study are based on an extensive review of existing evidence carried out for a previous study.[2]

7. The next part of this report identifies productivity gaps at the regional level across England and Wales, which is followed by an analysis of factors that explain these gaps. The subsequent section provides an in-depth focus on Wales and identifies whether the explanatory factors observed previously are particularly important for Wales. A

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[1] Office for National Statistics. (2015). *ABS, 2008-2013: Secure Access*. [Data collection]. *4th Edition*. UK Data Service. SN: 7451, http://dx.doi.org/10.5255/UKDA-SN-7451-4.

[2] See Boddy, M., J. Hudson, A. Plumridge and D. J. Webber (2005) "Meeting the productivity challenge," Report for the South West Regional Development Agency.

discussion of policy recommendations follows. Finally, the appendix provides a description of the variables used in generating the regressions estimates.

Regional productivity differentials and the Welsh productivity gap

8. This section examines regional productivity differentials between Wales and English regions.[3] Based on the regression estimates presented in tables A2 and A3 in the appendix, table 1 presents the initial productivity gaps across English and Welsh regions relative to the London. The figures for 2003, as stated in our 2006 report, are presented for comparison.

9. For additional insight, the 2012 results are separated into two columns corresponding to firms that have only one plant and to firms where the plant is part of a larger multi-plant business. Multi-plant businesses are arguably more efficient, with lower average costs that are spread across more plants potentially in a variety of regions. Their greater size permits more scale economies which further enhance productivity figures. Excluding or controlling for multi-plant firms in productivity estimations is required if a clearer understanding of 'local' productivity is to be achieved.

Table 1: Percentage points productivity gaps relative to London

Region name	2012 Single-plants	2012 incl. multi-plant	2003 All
Wales	31	18	42
North East	27	4	33
Yorkshire and Humberside	26	11	31
South West	26	10	33
West Midlands	24	9	30
East Midlands	22	10	32
North West	21	8	30
East	18	4	28
South East	6	7	21
London		*Benchmark*	

10. The first thing to note is that the 2003 productivity gap figures are larger than the corresponding 2012 figures. The 2012 headline productivity gaps of 31 percentage points between Wales and London for single-plant firms and 18 percentage points for multi-plant firms are lower than the corresponding headline figure using the 2003 data, which suggested that the overall productivity gap was 42 percentage points.[4]

[3] We take the view that the local authority districts of Scotland are not directly comparable to those in the rest of England and Wales because they are geographically larger authority areas and have a different education system. The size of the geographical area is particularly important as it is correlated with the geographical area of the firm's market and hence affects the spatial definition of the firm's monopolistically competitive market structure. Larger disparities between firms' market areas and administrative districts will confound the results. We therefore chose to exclude Scotland from our analysis.

[4] It should be noted that neither estimates are equivalent to the usual ONS figures for productivity based on aggregate data because this report explicitly employs firm-level data. In particular, the ONS corrects for sampling error in order to estimate aggregate regional productivity. Here we do not attempt this but seek to explain productivity differentials between firms in Wales and those in other regions.

11. The reduction in all regions' productivity gaps with London between these two time periods could be due to a range of issues, such as firms outside London increasing their productivity faster than firms in London or a greater slow down in productivity growth in London allowing other regions to close this gap. Although these two explanations are possible, the reductions in productivity gaps across all regions point to the relative importance of the productivity slowdown experienced in London.

12. As with all regions, the multi-plant productivity gap figure is much smaller than the single-plant figure. For instance, the North East's productivity gap with London is 27 percentage points for single-plant firms and only 4 percentage points for multi-plant firms. Further investigation (not provided here) showed that the over-representation of relatively highly productive (e.g. finance) multi-plant firms in the North East and the under-representation of relatively low productivity (e.g. hotel) multi-plant firms explains this anomaly. Although regression estimates are provided for both single-plant and all plants across Wales and England, focusing our analysis on the single-plant figures is likely to be more conducive for policy making that is geared towards helping the average firm in Wales not least because of the relative abundance of single-plant firms and the knowledge that such firms, which strongly tend to be small and medium enterprises, are known to be a major source of productivity growth as well as employment growth.

13. As with the results for 2003, the results for the single-plant firms in 2012 can be clustered into three groups, with the South East having the smallest productivity gap with London, Wales having the largest gap and a further group containing the remaining English regions somewhere in the middle. The similarity of these clusters in our two reports highlights consistency in the estimated results. On average, therefore, firms in Wales continue to perform relatively poorly when compared to firms across regions of England, and this requires investigation and explanation.

Explaining the Welsh Productivity Gap

14. This section examines whether the regional productivity gap between Wales and London region can be accounted for by a range of different factors.[5]

[5] This report contains slightly different variables than were included in 2006 report based on 2003 data. First, in this report we use the ABS data set, which is a reincarnation of the ARD dataset 2006 report, but unfortunately it does not include information allowing us to estimate the ratio of full-time to part-time workers employed within the firm. We understand from the ONS and Secure Data Service that such data were dropped in 2009. Second, with 70% of the workforce in the UK now having NVQs between 1 and 3 inclusive, and with the strong likelihood that productivity differentials between such individuals and those with no qualifications are diminishing (if such productivity differentials exist at all now once industry controls have been taken into account), we decided to focus on the more substantive issue of any gap between those with and without NVQs4+ (i.e. those with a degree). Moreover, when a more detailed breakdown of qualifications was included in the model they did not add any extra explanatory power of productivity gaps and qualitative interpretation of the distance estimate remained the same. Third, the 2006 report included a variable indicating whether outside users can access the company's website. This variable was excluded here because of a lack of variation in the variable and because firms without websites in the current period are unlikely to be responsive to any pressures placed on them to set up websites. Fourth, the 2006 report used 'other sectors' as the benchmark. It is good practice in econometric exercises to select a benchmark that is a larger proportion of a sample. Our 2012 sample illustrated that firms in the wholesale and retail sector should now be used as the benchmark due to their relative frequency, and this change also reflects the evolution in the business cycle between 2003 and 2012. This will adjust the estimates of the industry coefficients relative to the 2006 report.

15. The initial figure of a 31 percent productivity gap for single-plant firms between Wales and London is an estimate regardless of a range in other factors, such as differences in industrial structures, capital stocks, ownership and travel times. It reflects the fact that productivity in London is higher on average than in other regions, but it also highlights the gap between Wales and the English regions is large and significant. The 2003 estimate revealed a 9 percent gap between Wales and England's South West, and this figure has closed slightly such that the corresponding figure now stands at 5 percentage points, although this slight decrease could in part be due to rounding. Nevertheless, this 31 percentage point gap is considerable. It is much greater than the next group of regions – North East, Yorkshire and Humberside, South West, West Midlands, East Midlands, North West and East – which all have a productivity gap with London of between 18 and 27 percentage points.

16. A key issue concerns the ability to account for these productivity gaps and whether we can identify the relative importance of different contributory factors. The following analysis seeks to identify factors that are statistically associated with regional productivity gaps relative to London. The inclusion of the extra variables in the regressions enables us to explain all but 18 (12) percentage points of this Welsh productivity gap for single (all) plant firms. In other words, it is possible to explain a 42 (33) percent of the entire single (all) plant productivity gap, statistically speaking at least, in terms of these known and inherently plausible factors. Explanation of the remaining regional productivity differentials either lies outside of these variables or the effect of these explanatory variables is asymmetrically greater for Wales, and we shall return to this in the next section.

17. Starting with the headline figure for Wales, we can look in detail at the extent to which adding in additional explanatory variables progressively reduces the average productivity gap between businesses in Wales and in London. The exact definitions of productivity used here and of the factors included in the analysis are included in the appendix.

18. It is standard to estimate these models using either or both labour and capital stocks first and then augment the model with extra variables, such as industry and ownership. However, variables are, by their very nature, correlated with each other – such as capital stock and industrial structure – and the inclusion of one variable will capture some of effect of the excluded variable.

19. Adding capital stock and industrial structure into the analysis significantly reduces the productivity gap between Wales and London from 31 (18) to 30 (12) percentage points for single (all) plant firms, as shown in table 2. This suggests that if businesses in Wales had the same capital stock per worker and the same industrial structure as in London then productivity would be slightly higher for single plants and 33 percent higher across all plants, other things equal. The size of a firm's capital stock is likely to be correlated with their industry affiliation, as well as other unobservable managerial characteristics. Part of the effect of industrial composition on productivity is likely to be associated with the reduction in the productivity gap that is attributable to capital stocks. Differences in industrial composition are associated with the regional productivity gap, with some regions being affected more than others.

Table 2: Explaining the productivity gap between Wales and London

	Single plants	Incl. multi plants
Headline gap in productivity	31	18
Including capital stock and industrial structure	30	12
Including ownership, qualifications and population density	23	11
Including travel time	18	12

20. Adding in ownership structure, but also factors that are not firm-specific but instead are area specific, such as the qualifications of the local workforce and agglomeration economies captured via the population density variable, reduce the Welsh productivity gap relative to London by a further 7 percentage points (from 30 to 23) for single plants firms and marginally affects the estimate for the sample that includes multi-plant firms.

21. Finally, adding in the two travel-time variables, the average travel time to London and the next four largest conurbations (Birmingham, Manchester, Leeds and Glasgow) and the minimum time to any one of these, reduces the productivity gap between Wales and London for the single plant firms to only 18 percentage points. For the sample including multi-plant firms, the estimate is only marginally different (albeit upwards) from the previous estimate suggesting that for multi-plant firms ownership and accessibility explains nothing extra of this Welsh productivity gap.

22. Under the fitted model, these two distance variables together have a considerable impact on the productivity gap of some 5 percentage points for single plant firms. Inaccessibility clearly has major impacts on levels of productivity in Wales, including possible remoteness from major markets, specialist suppliers and services, larger pools of skilled labour or contact with other businesses and information sources. Note that the strong effect of travel time on productivity is not distinctive to Wales as it has particularly strong effects on the South West England regional economy too reducing that productivity gap from 17 to 9 percentage points for single plant firms.

23. Using data for 2012, we can therefore account for between 33 and 42 percent (depending on whether multi-plant firms are included) of the initial productivity gap between Wales and London in terms of a relatively limited set of straightforward and essentially plausible factors.

24. It is also possible to look at the effects of a given level of change in different factors on the productivity of the average firm; note that this applies to all firms in the data set and across England and Wales. Table 3 shows, not surprisingly, that productivity increases on average with greater capital stocks and a higher qualified local labour force, with the effect of greater population density on productivity being more nuanced. This does not necessarily indicate that increasing the skill levels of the local labour force will in itself drive up productivity, as more highly productivity businesses with a need for more skilled workers may tend to locate in areas where they can recruit such labour. But it clearly shows the association between productivity levels and worker skill levels.

25. Greater travel time to London and the next four largest cities in the UK is also shown to be associated with lower productivity levels. Although the actual time or monetary expense penalties of increasing inaccessibility are likely to be only small parts of the effects that are being identified here, there is now a large body of literature which

suggests that both inaccessibility and agglomeration economies (e.g. population density) are picking up positive impacts on productivity of proximity to large centres of population, employment and economic activity – and the negative effects of inaccessibility. It is possible to draw out these issues by using a more rigorous set of accessibility and peripherality indicators.

Table 3: Effects of different factors on the productivity of the average firm

	% change in productivity for single-plants	% change in productivity incl. multi-plants
A 10% increase in capital stock	0.583	0.958
A 10% increase in the percent of the local labour force with NVQ4+	0.967	0.038
A 10% increase in minimum travel time to London and the 4 next largest cities	-0.655	-0.200
A 10% increase in population density	0.114	-0.086

26. The effects of peripherality include the adverse effects on productivity of a lack of incentives for and a lack of achievement of economies of scale in production. Beneficial economies due to close proximity to markets and agglomeration are also associated with greater concentrations of specialist suppliers and sub-contractors, skilled workers, specialist services, better infrastructure, and greater opportunities for contact and collaboration with other businesses.

27. We can also examine the effects on productivity of different ownership types. Table 4 illustrates that overseas-owned businesses are on average by far the most productive business across England and Wales and there are also productivity benefits of being a multinational company that is UK-owned. In the case of the single-plant firms, this implies that it has sister plants overseas but not within the UK. The least productive firms are the UK-owned single site plants. The qualitative nature of these results is not surprising, as greater volumes of outputs connected to greater trade are likely to represent not only scale economies (that can push down input costs) but also a product quality that has international recognition (which can push up sale prices); both of these will increase the gross value added of the firm.

Table 4: Gap in productivity compared to the average UK-owned single plant firm

	% change in productivity for single plants	% change in productivity incl. multi-plants
UK owned single plant	*Benchmark*	
UK owned MNC	84	155
Overseas owned	192	265

28. There are significant differences in the average productivity of businesses across sectors, once the full range of other factors have been taken into account. As with all the estimates presented in this report update, the figures are likely to be different to the ones presented using the 2003 data as the business cycle affects countries, regions and industries differently. In table 5 we have wholesale and retail as the benchmark because

firms in this sector were very well represented in our data set. Relative to businesses in the wholesale and retail sector, businesses in the transport sector were more productive and businesses operating in the manufacturing sector are about as productive. Firms in the hotel and catering sector were amongst the least productive and a similar finding is presented for firms in the construction section. The difference in the estimates for the construction sector in 2012 relative to 2003 is a reflection of the housing market business cycle but also the different intensity of use of capital stocks and scale economies that exist within and across these sectors.

Table 5: Difference in levels of productivity between sectors

	% difference in productivity for single plants	% difference in productivity incl. multi-plants
Admin	-2	-15
Agriculture and mining	-16	-23
Construction	-24	-68
Education	-32	-75
Finance	-14	-38
Health	-38	-12
Hotel and catering	-49	-65
Manufacturing	-5	+4
Other sectors	-44	-66
Power	-13	-22
Real estate	-8	-27
Transport	+10	+102
Wholesale and retail	*Benchmark*	

29. From a statistical perspective, the results of this step-by-step process can only be seen as giving an indicative picture of the impact of different factors on productivity gaps. The apparent impact of different factors on productivity will vary depending on the order in which they are added to the model due to the relationships between the variables. This also explains why those factors added in last do not apparently add much to the explanation of the overall gap. The final model (appendix tables A2 and A3, column 6) indicates whether these variables have a statistically significant effect on productivity levels in the context of the model as a whole.

30. This final model which includes the complete range of variables is, statistically speaking, the most reliable picture of the importance of the different variables in explaining productivity. Most of the variables are statistically significant and the size of the coefficients attached to the different variables gives an indication of the relationship between the individual variables and levels of productivity.

31. Earlier we argued that the initial productivity gap between the Northeast and London is probably underestimated with the inclusion of multi-plant firms due to the relative over-representation of high productivity (e.g. finance) multi-plant firms and an under-representation of relatively low productive (e.g. hotel) multi-plant firms. In order to ensure that the inclusion of firms in the Northeast is not affecting the results for the rest of England and Wales we proceeded to re-estimate the model with the exclusion of those firms based in the Northeast; these results are presented in column 7 in tables A2 and A3

in the appendix. This stability check highlights that the results presented above are consistent and stable even after this exclusion, thereby enhancing our confidence in the results.

Are these factors more important for firms in Wales than for firms in England?

32. Unfortunately it has not been possible to explain the entire productivity gap between Wales and London using the same method that we employed in 2006. Nevertheless, it has been possible to explain 42 (33) percent of the entire single (all) plant productivity gap, statistically speaking at least, in terms of these known and inherently plausible factors.

33. Part of the reason for this lack of full explanation may be because we have implicitly assumed that the effects of the explanatory variables are the same across Wales and the English regions relative to London and that this assumption has become less applicable over time. This assumption can be relaxed by using compound variables. In this section we present re-estimate the models to identify not only the average effect of the variables on the productivity gaps (as before) but also identify whether the estimated effects are larger or smaller for Wales relative to England.

34. Table A4 presents the results of regressions which seek to identify whether the variables have stronger or weaker effects in Wales relative to England as a whole. For each individual regression there are now two columns of results that were estimated simultaneously: those corresponding for firms in England (column titled *standard*) and those for Wales (column called *compound*). The variables in the compound column are simply the same variables multiplied by the Wales dichotomous control variable. The results in this compound column signify whether the effects of these variables are stronger or weaker for firms in Wales than they are for firms in England.

35. The first thing to note from table A4 is that the variable named "Wales" is not statistically different from zero. This indicates that once the full range of variables and compound variables have been included in the model then we have been able to explain the productivity gap between Wales and England. The results are presented in summary form in table 6. An important column is the second one which highlights whether the effects of specific effects are statistically stronger or weaker in the Welsh economy than they are in the English economy, and the discussion below focuses only on those issues which are statistically different in Wales than in England.

36. Table 6 highlights that there are greater returns from additional employment on productivity in Wales than in England for multi-plant firms but the returns from increases in capital stock are smaller in Wales than in England. This may indicate that it is not necessarily a lack of capital that firms in Wales are experiencing, but a lack of appropriate workers or a lack of willingness to recruit more workers.

37. Also evident from table 6 is that the returns from UK-owned multinational businesses are larger in Wales but the returns from overseas-owned multinational businesses are slightly smaller in Wales, both relative to their effects in England. This may be a reflection of the type of firm that is attracted to Wales given its supply chains and how strong they are relative to other areas of the UK or it may reflect that UK-owned multinational businesses are particularly successful when they are located in Wales.

38. The benefits on productivity from firms in the agriculture, mining, real estate and transport sectors are also larger in Wales than in England, but this only applies to multi-plant businesses. Part of the reason for this may be the scale economies that a firm has through wider advertising and recognition of products across the UK with lower levels of competition within Wales and therefore greater potential productivity margins. Further investigation, perhaps through more qualitative means, is necessary to find out the reasons for these results.

Table 6: effects of factors on the productivity gap of the average firm in Wales

Variable	**Significant relative strength**	% change in productivity for single plants	% change in productivity incl. multi-plants
A 10% increase in employment	**Stronger**	(9)	5
A 10% increase in capital	**Weaker**	0	(1)
UK-owned multinationals relative to UK single plant firms	**Stronger**	134	117
Overseas-owned business relative to UK single plant firms	**Weaker**	77	222
Agriculture / mining relative to wholesale and retail	**Stronger**	(-39)	-7
Real estate relative to wholesale and retail	**Stronger**	(-29)	-7
Transport relative to wholesale and retail	**Stronger**	(-17)	243

Note: figures in brackets not statistically significant

Policy recommendations

39. Wales lags behind the regions of England in terms of productivity, based on firm level data. There is also a significant gap between Wales and the poorest English regions of the North East, Yorkshire and Humberside, South West, West Midlands, East Midlands, North West and East. Although the productivity gap has reduced since 2003, this reduction might be because of a slowdown in productivity growth by firms in London rather than an acceleration of productivity across the rest of the regions. There is clearly a serious issue to be addressed here.

40. A small part of the explanation for the productivity gap between Wales and London is attributable to the differences in industrial structure and variations in capital stocks. The effect of industrial structure and variations in capital stocks appear to be greater for multi-plant firms than for single-plant firms.

41. For single-plant firms, an important issue appears to be variations in company ownership. Policies geared towards encouraging UK-owned multinational businesses to locate in Wales may prove fruitful in enhancing the measure of productivity in Wales. An alternative policy could be to formulate stronger incentives to encourage managers to grow their business in Wales so that their businesses are more able to become multi-national.

42. The results also suggest that differences in the characteristics of the local economy including the qualifications of the local labour force and agglomeration economies (captured here through population density data) influence the productivity gap between Wales and London. A greater pool of qualified workers that reside in Wales could

stimulate higher productivity, as such workers tend to have higher incomes and greater purchasing power as well as being more productive in the labour market. Stronger incentives to encourage graduates to locate to Wales and stronger policies to discourage graduates from leaving Wales could also help.

43. An important part of the remaining productivity gap between Wales and London can be explained by differences in accessibility, and particularly so for single-plant firms. Reductions in the minimum travel time to core cities, and in particular Birmingham or Manchester, will permit greater abilities of Wales-based firms to compete more effectively in their markets as reduced travel time will save on costs.

44. All this raises the immediate policy issue of whether to attempt to raise productivity in those parts of the country where it is particularly low, whether to raise productivity at the aggregate level on grounds of equity, or whether to concentrate on those parts of the country that clearly have a degree of competitive advantage and where the returns on investment and policy effort might be greatest.

45. At the UK level, policy may be focused on enhancing returns on investment in the London region but this would accentuate the productivity gap and/or stimulate greater migration of skilled workers to the richer urban areas. An alternative and more equitable policy may well be to invest in firms that are not necessarily achieving their full potential, and this may well be because of a lack of a locally skilled workforce, agglomeration, capital stocks or inaccessibility.

46. The results presented in this report should not be interpreted in a mechanical sense, such that a given increase in capital stock or skills for example, if it could be achieved, would automatically result in a given change in productivity. The possibility of policy leverage and impact varies with different factors, circumstances and over time. The analysis does, however, point to those factors which, in combination, provide the conditions for higher or lower levels of productivity.

47. There is wide ranging evidence that skills and human capital are important drivers of productivity. However the results presented in this report suggest that there may be enough skilled labour in some areas of Wales and that the relative abundance of skilled labour is not necessarily the problem, at least no more so than it is in England. For instance, there appears to be large pools of skilled workers across Wales that may not be contributing significantly to increase productivity because, for example, they may be choosing to live in these sub-regions for lifestyle reasons and enhancing disposable income by increasing productivity may not be their sole aim or motivation.

48. The analysis indicates that there are considerable differences in productivity between different industrial sectors. However, the possibility of influencing the overall mix of industries is limited. Although the growth of financial and business services and high-value manufacturing would tend to increase levels of productivity, attracting and stimulating firms in those sectors is difficult as they tend to gravitate to core cities where there services are most in need. Furthermore, discouraging firms that operate at the low end of the productivity scale could also be counter-productive because supporting firms operating in the hotel and catering industries might result in a reduction in visitors to the area and hence a reduction in the inflow of money.

Appendices

Table A1: Variable definitions

Name	Definition
GVAfcpw	Gross value added at factor cost per worker in the business unit.
Employment	The number of workers in the business unit.
Capital	The capital stock of the business unit in constant prices. Source: Richard Harris.
No Quals	The proportion of the labour force that have no formal qualifications in the local authority district. Source: Neighbourhood Statistics.
Med Quals	The proportion of the labour force that have some but not 'high' qualifications in the local authority district. This is a control category. Source: Neighbourhood Statistics.
Hi Quals	The proportion of the labour force that have either a first degree, higher degree, NVQ levels 4 and 5, HNC, HND, qualified teacher status, qualified medical doctor, qualified dentist, qualified nurse, midwife or health visitor in the local authority district. Source: Neighbourhood Statistics.
Pop Den	The population density in the local authority district. Source: Neighbourhood Statistics.
UK owned Single	=1 if the business unit is a UK-owned single site firm. A control category.
UK owned MNC	=1 if the business unit is a UK-owned multinational.
Overseas Owned	=1 if the business unit is owned by an overseas investor.
Mfd	=1 if there is more than one plant in the business (a multi-plant dummy).
Ave Time	= the average time it takes by road, using legal speed limits, to travel between the centroid of a district in which the firm is located to the centroid of the five cities of Birmingham, Glasgow, Leeds, Manchester and Westminster. Source: authors' estimations
Min Time	= the time it takes by road, using legal speed limits, to travel between the centroid of a district to the nearest centroids of either of the five cities of Birmingham, Glasgow, Leeds, Manchester and Westminster. Source: authors' estimations
North West	= 1 if the firm is located in the North West region and =0 (zero) otherwise
Yorkshire and Humberside	= 1 if the firm is located in the Yorkshire and Humberside region and =0 (zero) otherwise
North East	= 1 if the firm is located in the North East region and =0 (zero) otherwise
West Mids	= 1 if the firm is located in the West Midlands region and =0 (zero) otherwise
Wales	= 1 if the firm is located in the Wales region and =0 (zero) otherwise
South West	= 1 if the firm is located in the South West region and =0 (zero) otherwise
East Mids	= 1 if the firm is located in the East Midlands region and =0 (zero) otherwise
East	= 1 if the firm is located in the East region and =0 (zero) otherwise
SouthEast	= 1 if the firm is located in the South East region and =0 (zero) otherwise
London	= 1 if the firm is located in the London region and =0 (zero) otherwise. A control category.
Admin	= 1 if the firm is listed within the SIC codes between 75000 and 79999 and =0 (zero) otherwise
Agriculture and mining	= 1 if the firm is listed within the SIC codes between 0 and 14999 and =0 (zero) otherwise
Construction	= 1 if the firm is listed within the SIC codes between 45000 and 49999 and =0 (zero) otherwise
Education	= 1 if the firm is listed within the SIC codes between 80000 and 84999 and =0 (zero) otherwise
Finance	= 1 if the firm is listed within the SIC codes between 65000 and 69999 and =0 (zero) otherwise
Health	= 1 if the firm is listed within the SIC codes between 85000 and 89999 and =0 (zero) otherwise
Hotels	= 1 if the firm is listed within the SIC codes between 55000 and 59999 and =0 (zero) otherwise
Manu	= 1 if the firm is listed within the SIC codes between 15000 and 39999 and =0 (zero) otherwise
Other Sectors	= 1 if the firm is listed within the SIC codes between 90000 and 100000 and =0 (zero) otherwise
Power	= 1 if the firm is listed within the SIC codes between 40000 and 44999 and =0 (zero) otherwise
Real Estate	= 1 if the firm is listed within the SIC codes between 70000 and 74999 and =0 (zero) otherwise
Transport	= 1 if the firm is listed within the SIC codes between 60000 and 64999 and =0 (zero) otherwise
Wholesale and retail	= 1 if the firm is listed within the SIC codes between 50000 and 54999 and =0 (zero) otherwise. A control category.
livelu	The number of plants which make up the business unit.

Notes: all variables that are continuous are estimated in natural logarithms. Dataset source unless otherwise stated: ABS. Source: ONS.

Table A2: Regression results excluding multi-plant firms

		1	2	3	4	5	6
	n	35,021	26,235	26,235	22,506	22,506	21,877
Policy controls	Employment	1.044 (0.004)***	0.937 (0.007)***	0.977 (0.007)***	0.909 (0.008)***	0.909 (0.008)***	0.909 (0.008)***
	Capital		0.118 (0.005)***	0.089 (0.005)***	0.061 (0.006)***	0.061 (0.006)***	0.060 (0.006)***
	Hi Quals				0.161 (0.040)***	0.101 (0.041)**	0.098 (0.042)**
	Low/no quals			*Control / benchmark*			
	Population density				0.034 (0.008)***	0.012 (0.009)	0.013 (0.009)
	UK owned single plant			*Control / benchmark*			
	UK owned MNC				0.612 (0.028)***	0.610 (0.028)***	0.621 (0.028)***
	Overseas owned				1.077 (0.044)***	1.071 (0.044)***	1.083 (0.045)***
	Average time					-0.046 (0.070)	-0.046 (0.070)
	Minimum time					-0.069 (0.016)***	-0.068 (0.016)***
Regional controls	North West	-0.230 (0.028)***	-0.247 (0.031)***	-0.255 (0.030)***	-0.168 (0.040)***	-0.199 (0.054)***	-0.199 (0.054)***
	Yorks Humbs	-0.303 (0.031)***	-0.333 (0.034)***	-0.337 (0.034)***	-0.233 (0.045)***	-0.272 (0.056)***	-0.273 (0.057)***
	North East	-0.308 (0.048)***	-0.347 (0.054)***	-0.350 (0.054)***	-0.218 (0.061)***	-0.158 (0.067)**	*Excluded*
	West Mids	-0.277 (0.029)***	-0.288 (0.032)***	-0.304 (0.032)***	-0.212 (0.043)***	-0.267 (0.051)***	-0.268 (0.051)***
	Wales	-0.371 (0.044)***	-0.384 (0.048)***	-0.353 (0.048)***	-0.262 (0.055)***	-0.203 (0.060)***	-0.204 (0.060)***
	South West	-0.301 (0.028)***	-0.308 (0.032)***	-0.298 (0.031)***	-0.183 (0.044)***	-0.092 (0.047)*	-0.093 (0.047)*
	East Mids	-0.251 (0.031)***	-0.249 (0.034)***	-0.254 (0.034)***	-0.130 (0.048)***	-0.112 (0.058)*	-0.113 (0.058)*
	East	-0.193 (0.027)***	-0.246 (0.031)***	-0.260 (0.030)***	-0.167 (0.042)***	-0.134 (0.045)***	-0.134 (0.045)***
	South East	-0.059 (0.023)**	-0.066 (0.026)**	-0.078 (0.025)***	-0.027 (0.036)	0.022 (0.038)	0.021 (0.038)
	London			*Control / benchmark*			
Sector controls	Admin			-0.118 (0.069)*	-0.019 (0.073)	-0.025 (0.073)	-0.019 (0.074)
	Agri / mining			-0.257 (0.075)***	-0.180 (0.080)**	-0.179 (0.080)**	-0.161 (0.082)**
	Construction			-0.331 (0.058)***	-0.268 (0.062)***	-0.273 (0.062)***	-0.259 (0.063)***
	Education			-0.444 (0.067)***	-0.385 (0.070)***	-0.391 (0.070)***	-0.378 (0.071)***
	Finance			-0.129 (0.063)**	-0.144 (0.068)**	-0.153 (0.068)**	-0.141 (0.069)**
	Health			-0.656 (0.224)***	-0.478 (0.247)*	-0.475 (0.247)*	-0.462 (0.247)*
	Hotels			-0.819 (0.064)***	-0.673 (0.068)***	-0.677 (0.068)***	-0.659 (0.069)***
	Manufacturing			-0.052 (0.060)	-0.047 (0.064)	-0.052 (0.064)	-0.042 (0.065)
	Other sectors			-0.684 (0.063)***	-0.576 (0.068)***	-0.582 (0.068)***	-0.555 (0.069)***
	Power			0.252 (0.077)***	-0.149 (0.081)*	-0.140 (0.081)*	-0.138 (0.083)*
	Real estate			0.093 (0.061)	-0.095 (0.065)	-0.088 (0.065)	0.101 (0.066)
	Transport			0.031 (0.066)	0.102 (0.070)	0.097 (0.070)	0.109 (0.071)
	Wholesale and retail			*Control / benchmark*			
	F test	5,899.38***	4,520.60***	2,306.99***	1,786.41***	1,666.11***	1,673.93***
	R^2	0.628	0.655	0.669	0.682	0.683	0.682

Notes: The dependent variable is the natural logarithm of GVAfc. Continuous independent variables are also expressed in natural logarithms. Intercept estimates omitted. ***, ** and * signify statistical significance at the 1%, 5% and 10% confidence levels respectively. Source: ONS.

Table A3: Regression results including multi-plant firms

		1	2	3	4	5	6
	n	265,335	224,264	224,264	181,916	181,916	174,147
Policy controls	Employment	0.593 (0.002)***	0.440 (0.002)***	0.479 (0.002)***	0.459 (0.003)***	0.458 (0.003)***	0.459 (0.003)***
	Capital		0.158 (0.001)***	0.107 (0.001)***	0.100 (0.001)***	0.100 (0.001)***	0.099 (0.001)***
	Hi Quals				0.018 (0.013)	0.004 (0.013)	0.000 (0.013)
	Low/no quals				*Control / benchmark*		
	Population density				-0.003 (0.002)	-0.009 (0.003)***	-0.009 (0.003)***
	UK owned single plant				*Control / benchmark*		
	UK owned MNC				0.937 (0.011)***	0.937 (0.011)***	0.940 (0.011)***
	Overseas owned				1.294 (0.012)***	1.294 (0.012)***	1.296 (0.012)***
	Average time					0.027 (0.022)	0.025 (0.022)
	Minimum time					-0.021 (0.005)***	-0.022 (0.005)***
Regional controls	North West	-0.080 (0.010)***	-0.084 (0.010)***	-0.088 (0.009)***	-0.119 (0.013)***	-0.084 (0.010)***	-0.110 (0.017)***
	Yorks Humbs	-0.118 (0.011)***	-0.126 (0.011)***	-0.124 (0.011)***	-0.154 (0.014)***	-0.126 (0.011)***	-0.149 (0.018***
	North East	-0.045 (0.015)***	-0.046 (0.015)***	-0.052 (0.014)***	-0.084 (0.017)***	-0.046 (0.015)***	*excluded*
	West Mids	-0.090 (0.011)***	-0.073 (0.011)***	-0.083 (0.010)***	-0.098 (0.014)***	-0.073 (0.011)***	-0.101 (0.016)***
	Wales	-0.193 (0.014)***	-0.124 (0.015)***	-0.124 (0.014)***	-0.122 (0.017)***	-0.124 (0.015)***	-0.097 (0.018)***
	South West	-0.107 (0.011)***	-0.068 (0.011)***	-0.092 (0.010)***	-0.098 (0.014)***	-0.068 (0.011)***	-0.070 (0.015)***
	East Mids	-0.107 (0.012)***	-0.083 (0.012)***	-0.093 (0.012)***	-0.098 (0.015)***	-0.083 (0.012)***	-0.075 (0.018)***
	East	-0.045 (0.011)***	-0.047 (0.011)***	-0.072 (0.010)***	-0.087 (0.014)***	-0.047 (0.011)***	-0.070 (0.015)***
	South East	-0.071 (0.009)***	-0.069 (0.009)***	-0.082 (0.009)***	-0.092 (0.012)***	-0.069 (0.009)***	-0.075 (0.012)***
	London				*Control / benchmark*		
Sector controls	Admin			-0.167 (0.018)***	-0.281 (0.019)***	-0.167 (0.018)***	-0.277 (0.019)***
	Agri / mining			-0.266 (0.028)***	-0.435 (0.030)***	-0.266 (0.028)***	-0.418 (0.030)***
	Construction			-1.133 (0.013)***	-1.112 (0.014)***	-1.133 (0.013)***	-1.113 (0.014)***
	Education			-1.397 (0.017)***	-1.435 (0.017)***	-1.397 (0.017)***	-1.439 (0.018)***
	Finance			-0.475 (0.017)***	-0.281 (0.018)***	-0.475 (0.017)***	-0.289 (0.019)***
	Health			-0.126 (0.094)	-0.085 (0.092)	-0.126 (0.094)	-0.090 (0.093)
	Hotels			-1.037 (0.015)***	-0.975 (0.015)***	-1.037 (0.015)***	-0.974 (0.016)***
	Manufacturing			0.035 (0.018)**	-0.175 (0.019)**	0.035 (0.018)**	0.176 (0.019)***
	Other sectors			-1.096 (0.016)***	-1.019 (0.016)***	-1.096 (0.016)***	-1.024 (0.017)***
	Power			-0.246 (0.041)***	-0.278 (0.041)***	-0.246 (0.041)***	-0.284 (0.041)***
	Real estate			-0.313 (0.019)***	-0.321 (0.019)***	-0.313 (0.019)***	-0.324 (0.020)***
	Transport			0.708 (0.020)***	0.655 (0.020)***	0.708 (0.020)***	0.652 (0.021)***
	Wholesale and retail				*Control / benchmark*		
	livelu	0.837 (0.002)***	0.863 (0.002)***	0.911 (0.002)***	0.867 (0.002)***	0.863 (0.002)***	0.868 (0.002)***
	mfd	1.474 (0.012)***	1.341 (0.012)***	1.359 (0.012)***	0.840 (0.013)***	1.341 (0.012)***	0.833 (0.013)***
	F test	74,973.52***	69,719.19***	39,946.46***	33,047.33***	30,919.35***	30,625.93***
	R^2	0.772	0.790	0.817	0.841	0.841	0.841

Notes: The dependent variable is the natural logarithm of GVAfc. Continuous independent variables are also expressed in natural logarithms. Intercept estimates omitted. ***, ** and * signify statistical significance at the 1%, 5% and 10% confidence levels respectively. Source: ONS.

Table A4: Regression results with interaction terms

		Excluding multi-plant firms		Including multi-plant firms	
	n	22,506		181,916	
		Standard	Compound	Standard	Compound
Policy controls	Wales		-1.805 (2.583)		-1.182 (0.743)
	Employment	0.907 (0.008)***	0.040 (0.043)	0.457 (0.003)***	0.028 (0.013)***
	Capital	0.062 (0.006)***	-0.051 (0.030)*	0.100 (0.001)***	-0.004 (0.007)
	Hi Quals	0.205 (0.037)***	-0.286 (0.346)	0.039 (0.012)***	-0.102 (0.098)
	Low/no quals		*Control / benchmark*		
	Population density	0.025 (0.008)***	-0.017 (0.037)	-0.002 (0.003)	0.017 (0.011)
	UK owned single plant		*Control / benchmark*		
	UK owned MNC	0.602 (0.028)***	0.250 (0.151)*	0.944 (0.011)***	-0.168 (0.051)***
	Overseas owned	1.111 (0.045)***	-0.542 (0.224)**	1.299 (0.012)***	-0.130 (0.056)**
	Average time	0.209 (0.044)***	1.013 (0.897)	0.107 (0.014)***	0.374 (0.257)
	Minimum time	-0.065 (0.014)***	-0.579 (0.382)	-0.027 (0.004)***	-0.165 (0.111)
Sector controls	Admin	-0.016 (0.074)	-0.218 (0.444)	-0.283 (0.019)***	0.009 (0.086)
	Agri / mining	-0.176 (0.082)**	-0.320 (0.448)	-0.461 (0.030)***	0.393 (0.129)***
	Construction	-0.272 (0.063)***	-0.163 (0.398)	-1.114 (0.014)***	0.005 (0.057)
	Education	-0.380 (0.071)***	-0.292 (0.444)	-1.437 (0.018)***	-0.051 (0.087)
	Finance	-0.150 (0.069)**	-0.286 (0.445)	-0.290 (0.019)***	0.097 (0.103)
	Health	-0.470 (0.247)*	*Omitted: Too few obs.*	-0.089 (0.093)	-0.182 (0.681)
	Hotels	-0.681 (0.070)***	-0.100 (0.413)	-0.980 (0.016)***	0.074 (0.074)
	Manufacturing	-0.062 (0.065)	0.034 (0.403)	-0.183 (0.019)**	0.124 (0.087)
	Other sectors	-0.567 (0.069)***	-0.406 (0.424)	-1.023 (0.017)***	0.059 (0.078)
	Power	0.143 (0.083)*	-0.209 (0.500)	-0.288 (0.041)***	0.235 (0.243)
	Real estate	0.102 (0.066)	-0.445 (0.419)	-0.334 (0.020)***	0.259 (0.104)**
	Transport	0.113 (0.071)	-0.297 (0.466)	0.628 (0.021)***	0.606 (0.101)***
	Wholesale and retail		*Control / benchmark*		
	lnlivelu			0.866 (0.002)***	0.027 (0.008)***
	Mfd			0.836 (0.013)***	0.043 (0.062)
	F test	1,204.80***		21,299.61***	
	R^2	0.682		0.841	

Notes: The dependent variable is the natural logarithm of GVAfc. Continuous independent variables are also expressed in natural logarithms. Intercept estimates omitted. ***, ** and * signify statistical significance at the 1%, 5% and 10% confidence levels respectively. Source: ONS.