Productivity and Proximity

Don J. Webber[1] and Paul White[2]

[1] *School of Economics, University of the West of England, Bristol, UK*
[2] *Department of Mathematics and Statistics, University of the West of England, Bristol, UK*

Abstract: Papers examining a developed nation's labour productivity frequently ignore spatial effects. We present empirical results indicating that geographical proximity matters for plant-level productivity.

Acknowledgements: The authors thank Paul Dunne and Peter Howells for helpful comments on an earlier draft. This work contains statistical data from the Office for National Statistics 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. Any errors are the authors' responsibility.

Keywords: distance; labour productivity

JEL Classification: C21; R32

Corresponding Author: Dr Don J Webber, School of Economics, Bristol Business School, University of the West of England, Bristol, BS16 1QY. E-mail: Don.Webber@uwe.ac.uk. Tel.: (+44/0) 117 328 2741. Fax: (+44/0) 117 328 2289

1. Introduction

Empirical analyses of within country spatial labour productivity variations typically focus on either agglomeration economies present within cities and their variations between conurbations, or the variation in and evolution of average labour productivity at an aggregate geographical level, such as the county, state, or prefecture. This may be due to a chosen focus on administrative regions or restrictive availability of data at a more disaggregated level.

Both of these approaches avoid the explicit calibration of the trade-off between labour productivity and distance from the core. Evidence of such a trade-off, essentially linking productivity to proximity, has repercussions for economic theory (Bivand, 2008). For instance, theories of monopolistic competition often cite space as an insulating factor that allows spatially segregated firms to charge higher prices. The frequently cited example is the petrol/gas station where greater distances between forecourts mean drivers often pay higher petrol prices in rural areas rather than paying the additional cost of travelling to a cheaper forecourt. As such spatially segregated firms produce low quantities but charge high prices it appears that their productivity is high. This points to the possibility of a U-shaped relationship between productivity and proximity. Nevertheless the ability of a range of firms to compete on price in a region's core city's central business district reduces with greater transportation costs, which suggests the presence of a negative relationship as value added per worker would be squeezed to compensate for transportation costs. These relationships may well have changed over time (Glaeser and Kohlhase, 2004) but the death of the importance of distance may well be premature (Reitveld and Vickerman, 2004).

In spite of these generalisations there is a lack of empirical evidence supporting the presence of a productivity–proximity trade-off. This paper fills this gap in the literature by presenting an empirical investigation into the influence of distance on labour productivity. We employ data for 16,410 plants within England which we match at the district level to distance data to the region's core city's central business district.

2. Model

The natural logarithm of plant-level labour productivity is modelled using OLS regression. Potential predictors include the natural logarithms of employment and capital stock per worker, local distance and a dummy variable to indicate plant status. The modelling strategy is to extend the regression model by including a quadratic term for local distance and to further extend by including a cubic term for local distance. The inclusion of the quadratic term and the cubic term has the potential to induce a high degree of undesirable correlation between predictors. For this reason we isolate the unique quadratic effect and the unique cubic effect using an orthogonal quadratic term and an orthogonal cubic term using the Gram-Schmidt orthogonalisation process (see Draper and Smith, 1981). The model is extended by the inclusion of interaction terms between the multi-plant dummy variable and all other predictors so as to ascertain whether the rate of change of labour productivity differentially varies with the predictors according to plant status.

3. Data

Factors influencing labour productivity ultimately act by influencing the operational performance of firms. Analyzing business performance at the plant-level overcomes the shortcomings of working with aggregate data, in particular by providing an unambiguous association between output and the workforce responsible for generating it. In this analysis we use data held by the UK government's Office for National Statistics in their Annual Respondents Database (ARD) (ONS, 2002), which includes data on the number of employees, output and the amount of capital stock which relates to individual business units. Data on firm-specific capital stock is obtainable from the ONS and is matched with plant-specific data within the ARD. One issue with the ARD is the level at which the data are collected: we use the plant. However, plants can be members of larger firms and to control for this we employ a dummy equal to one if the plant comes from a firm with more than one plant and equal to zero otherwise.

The district in which the plant is located is identifiable from the ARD. For simplicity, UK districts are sub-divisions of counties, and counties are subdivisions of regions – the UK has 9 administrative regions. We calculate the distance between each plant's district location and the central business district of their region's core city. Distance data is sourced separately from the AA website (www.theAA.com). Essentially this 'local distance' reflects the level of past infrastructural investment and is responsive to long term policy initiatives to improve transport infrastructure. The longer the period of time it takes to move goods to the location of consumption or intermediate productive use then the greater will be the incurred transportation costs and the less competitive the firm will be in the region's core market place.

4. Results

Table 1 provides means and standard deviations for the logarithm of labour productivity and for all potential predictor variables. The average distance from a plant's district to a region's core city's central business district is 34 miles. This distance varies from zero (where the plant is located in the region's core city's central business district) to 195 (where the plant is located in the Isles of Scilly).

Table 2 summarises the regression models without consideration of interaction terms involving plant status. In Model 1a there is a statistically significant average increase in the logarithm of labour productivity with labour productivity increasing by a factor of 1.06 for multi-plant organisations compared with single plant organisations ($p<0.001$). In regression Model 1a a doubling of capital stock per worker is associated with labour productivity increasing by a factor of 1.2 ($p<0.001$). Also note that there is evidence of decreasing returns to scale from the employment variable. These effects are essentially constant irrespective of whether quadratic or cubic terms for local distance are included in the model (see Model 1a to 5a, Table 2).

In the fitted model (Model 1a, Table 2) there is a statistically significant negative linear association between local distance and the logarithm of labour productivity ($p<0.001$), with a ten mile decrease in local distance being associated with labour productivity increasing by a factor of 1.03. The square of local distance produces an additional statistically significant unique effect (see Model 2a and Model 4a, Table 2) and the same can be seen for the cube of local distance (see Model 3a and Model 5a, Table 2). A graphical summary of the cubic model (for single and multi-plant firms) is given in Figure 1 and this graphic is based on the logarithm of capital stock per worker and logarithm of employment held at mean values.

Table 3 summarises the regression models which include interaction effects with plant status and all other predictors. All models in Table 3 capture a statistically significant interaction between plant status and logarithm of capital stock per worker on the logarithm of labour productivity with a doubling of capital stock per worker being associated with labour productivity increasing by a factor of 1.19 for single plant firms and increasing by a factor of 1.24 for multi-plant firms; this difference in effects is statistically significant ($p<0.001$). Interestingly there is evidence from the interaction between plant status and logarithm of employment that single plant firms do not suffer from diseconomies of scale and that this is a characteristics of multi-plant firms in general. Nevertheless in all models in Table 3 there is no differential effect between linear ($p=0.245$), quadratic ($p=0.527$) and cubic ($p=0.614$) local distance with logarithm of productivity and plant status.

The repercussion of these results is that technological improvements that have facilitated declines in distance costs have not resulted in an eradication of the spatial labour productivity divide across English regions.

5. Conclusion

The results from our regression analyses suggest that proximity to a region's core city is negatively related to plant-level labour productivity within England.

References

Bivand, R., 2008. Implementing representations of space in economic geography. Journal of Regional Science 48, 1-27

Draper, N. and Smith, H., 1981. Applied regression analysis, John Wiley and Sons, New York

Glaeser, E.L. and Kohlhase, J.E. 2004. Cities, regions and the decline of transport costs. Papers in Regional Science 83, 197-228

Reitveld, P. and Vickerman, R. 2004. Transport in regional science: The "death of distance" is premature. Papers in Regional Science 83, 229-248

Table 1: Descriptive statistics

	Mean	Median
Log of labour productivity	3.289	3.342
Log of capital stock per worker	3.297	3.373
Log of employment	3.804	4.025
Local distance in miles	34.290	28.000
Local distance in miles^2	2111.991	784.000
Local distance in miles^3	176844	21952
Log of capital stock per worker * multi-plant dummy	1.254	0
Log of employment * multi-plant dummy	1.974	0
Local distance in miles * multi-plant dummy	11.649	0
Local distance in miles^2 * multi-plant dummy	711.675	0
Local distance in miles^3 * multi-plant dummy	59445.36	0

n=16,410

Table 2: Regression Models

	1a	2a	3a	4a	5a
Log (capital stock per worker)	0.275** (0.005)	0.275** (0.005)	0.275** (0.005)	0.275** (0.005)	0.275** (0.005)
Log (employment)	-0.015** (0.004)	-0.015** (0.004)	-0.015** (0.004)	-0.015** (0.004)	-0.015** (0.004)
Local distance in miles	-0.003** (2.35e-04)	-0.004** (0.001)	-0.008** (0.001)	-0.003** (2.35e-04)	-0.003** (2.35-e04)
Local distance in miles^2	–	1.33e-05** (4.55e-06)	9.37e-05** (2.07e-05)	–	–
Local distance in miles^3	–	–	-3.66e-07** (9.19e-08)	–	–
Orthogonal local distance^2	–	–	–	1.33e-05** (4.55e-06)	1.34e-05** (4.54e-06)
Orthogonal local distance^3	–	–	–		-3.66e-07** (9.19e-08)
Multi-plant dummy	0.058** (0.019)	0.058** (0.019)	0.057** (0.019)	0.058** (0.019)	0.057** (0.019)
Constant	2.513** (0.022)	2.538** (0.024)	2.574** (0.025)	2.515** (0.022)	2.517* (0.022)
F (prob.)	946.95** (<0.001)	759.61** (<0.001)	636.22** (<0.001)	759.61** (<0.001)	636.22** (<0.001)
R^2	0.188	0.188	0.189	0.188	0.189

Notes: n=16,410. ** indicates statistical significance at the 1% level.

Table 3: Regressions with compound variables

	1b	2b	3b	4b	5b
Log (capital stock per worker)	0.257** (0.005)	0.257** (0.005)	0.257** (0.005)	0.257** (0.005)	0.257** (0.005)
Log (employment)	-0.005 (0.005)	-0.005 (0.005)	-0.005 (0.005)	-0.005 (0.005)	-0.005 (0.005)
Local distance in miles	-0.003** (2.87e-04)	-0.004** (0.001)	-0.009** (0.001)	-0.003** (2.87e-04)	-0.003** (2.87e-04)
Local distance in miles^2	–	1.55e-05** (5.56e-06)	1.06e-04** (2.51e-05)	–	–
Local distance in miles^3	–	–	-4.08e-07** (1.11e-07)	–	–
Orthogonal local distance^2	–	–	–	1.57e-05** (5.63e-06)	1.68e-05** (5.64e-06)
Orthogonal local distance^3	–	–	–	–	-4.16e-07** (1.13e-07)
Log (capital stock per worker) * Multi-plant dummy	0.055** (0.008)	0.054** (0.009)	0.053** (0.009)	0.055** (0.008)	0.055** (0.008)
Log (employment) * Multi-plant dummy	-0.031** (0.006)	-0.032** (0.007)	-0.034** (0.007)	-0.031** (0.006)	-0.032** (0.006)
Local distance in miles * Multi-plant dummy	5.41e-04 (4.66e-04)	0.001 (0.001)	0.002 (0.002)	0.001 (4.66e-04)	6.14e-04 (4.66e-04)
Local distance in miles^2 * Multi-plant dummy	–	-5.81e-06 (9.19e-06)	-2.81e-05 (4.12e-05)	–	–
Local distance in miles^3 * Multi-plant dummy	–	–	9.45e-08 (1.87e-07)	–	–
Orthogonal local distance^2 * Multi-plant dummy	–	–	–	-6.38e-06 (9.53e-06)	-8.38e-06 (9.54e-06)
Orthogonal local distance^3 * Multi-plant dummy	–	–	–	–	1.18e-07 (1.95e-07)
Constant	2.547** (0.023)	2.575** (0.025)	2.615** (0.027)	2.550** (0.023)	2.552** (0.023)
F (prob.)	639.59** (<0.001)	481.06** (<0.001)	386.90** (<0.001)	481.07** (<0.001)	386.93** (<0.001)
R^2	0.189	0.190	0.191	0.190	0.191

Notes: see notes on Table 1

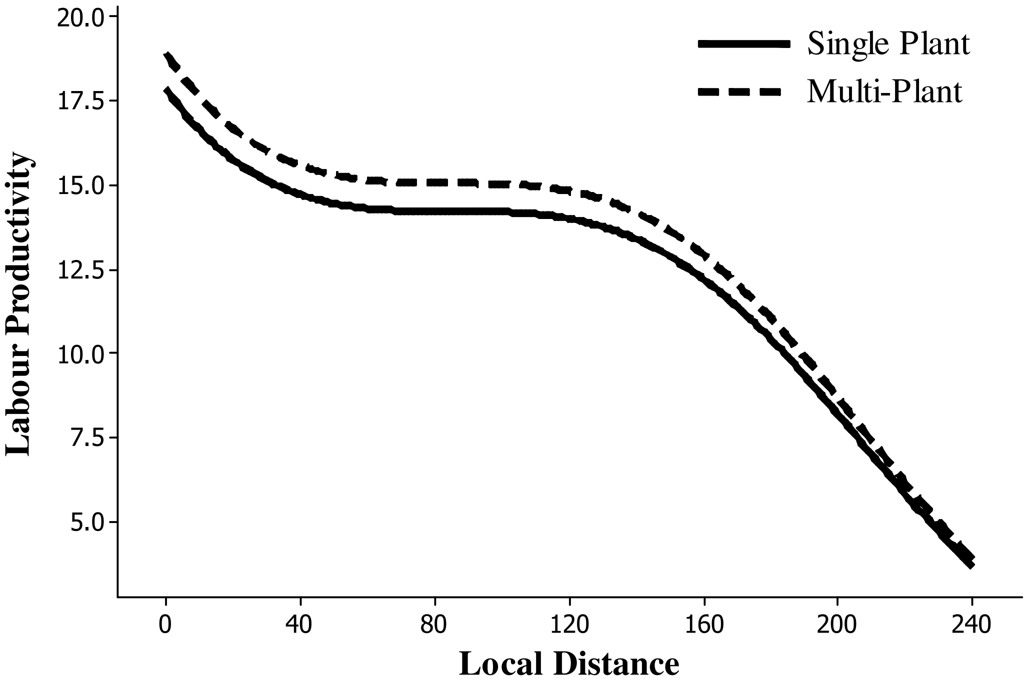

Figure 1: Local distance and labour productivity