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The new economic geography versus urban economics : an evaluation using local wage rates in Great Britain

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Abstract

This paper tests two competing models, one deriving from new economic geography theory (NEG) emphasising varying market potential, the other with a basis in urban economics theory (UE) in which the main emphasis is on producer service linkages. Using wage rate variations across small regions of Great Britain, the paper finds that, taking commuting into account, it is UE theory rather than NEG theory that has explanatory power. However since the two hypotheses are non-nested, the evaluation of the competing hypotheses is difficult and therefore the conclusions are provisional. Nevertheless this paper provides evidence that we should be cautious about the ability of NEG to work at all levels of spatial resolution, and re-emphasises the need to focus on supply-side variations in producer services inputs and labour efficiency variations, including the role of commuting, in local economic analysis.

Introduction

As acknowledge by Head and Mayer(2003), the wage equation is one of the most successful equations deriving from the new economic geography (NEG). There is strong evidence from a number of studies, such as the often-cited paper by Hanson(1997), that wages increase in market potential or access, in line with the theoretical predictions set out in the standard NEG literature (Fujita, Krugman and Venables, 1999). Market potential is a long-established concept that goes right back to the work of Harris(1954), but it has been given a new lease of life as a fundamental part of NEG theory. The key element is that firms have differing levels of market potentials according to their level of access to their own and neighbouring markets, with access depending on friction of distance costs, the size of the markets and the competition within markets, with good market access associated with higher wage levels.

The aim of this paper is to test whether the success of the NEG wage equation is replicated in data for very small regions in the UK, under the challenge of a competing theory of wage level determination and the need to control for additional effects. The paper thus estimates an NEG-motivated wage equation and compares the results with the alternative but related urban economics (UE) model which denies any role for market potential, attributing a primary cause of wage variation to the pecuniary externalities deriving from the presence of service sector linkages which are particularly evident in urban areas, so that in this UE set-up wages increase with the density of productive activity (Ciccone and Hall, 1996, Rivera-Batiz, 1988, Abdel Rahman and Fujita, 1990, Fingleton, 2003). In contrast, there are rarely any UE-style links in NEG theory, although Venables(1996) and Krugman and Venables(1995) explicitly model intersectoral linkages[1], and de Vaal and van den Berg (1999) develop

[1] Venables(1996) modified Krugman by eliminating labour migration, and introducing monopolistically competitive industries in an upstream-downstream relationship. Having suppliers close-by cuts costs, and suppliers having their customer firms near-by also benefits them. With low transport costs, agglomeration increases. With even lower transport costs, we see production costs becoming more dominant compared with transport costs, so that low periphery wages attract manufacturers, agglomeration starts to break down. There is a non-monotonic relationship between transport costs and agglomeration, a U shaped curve. Krugman and Venables(1995) use this type of model to explain the impact of globalization. First we saw increasing discrepancies between core (the developed world) and periphery as transport costs fell in the 1960s and 1970s. However, more recently it is the core that has lost manufacturing activity. As transport or trade costs have continued to fall, the

a hybrid model in which producer service linkages are incorporated into an NEG model. In this paper a clear distinction between UE and NEG theory is (for the most part) retained, with models derived from UE theory omitting the market potential effects that are at the core of NEG theory, and NEG-based models omitting UE-style linkages. The paper focuses on the relative explanatory power of these two competing hypotheses.

The NEG wage equations

The relationship between nominal wage levels and market access is as set out in Fujita, Krugman and Venables (1999). They assume that the economy is divided into competitive (*C*) and monopolistically competitive (*M*) sectors, so that the (short-run) equilibrium *M* wages occasioned by the fast entry and exit of firms driving profits to zero are

$$w_i^M = \frac{\overline{W}_i^M}{E_i^M} = [\sum_r Y_r (G_r^M)^{\sigma-1} (\overline{T}_{ir})^{1-\sigma}]^{\frac{1}{\sigma}} = P^{\frac{1}{\sigma}} \quad (1)$$

in which i denotes region, $\overline{W}_i^M$ is area i's total *M* wage bill, E_i^M is the *M* workforce, and the summation is over the set of regions including i. The transport cost is $\overline{T}_{ir}$, G_r^M denotes *M* prices, Y_r denotes income and σ is the elasticity of substitution for *M* varieties. In contrast, since in this set up *C* goods are freely transported and produced under constant returns, *C* wages w_i^C are constant across regions.

In the paper I make the (perhaps strong) assumption that the *M* sector is equivalent to Market Services, while all other sectors are *C* activities. I define Market Services (*M* activities) as the Banking, Finance and Insurance etc subgroup of the UK's 1992 Standard Industrial Classification (see Appendix table). The reason is based on the approximate equivalence of firms in the markets service sector to the theoretical assumptions of monopolistic competition. It is also based on the precedence set in the

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lower production costs (ie wages) in the periphery cause them to attract a greater share of manufacturing. Proximity is now less important and production costs matter more.

earlier UE literature. In contrast, it is common in the NEG[2] literature to assume that manufacturing is the *M* sector. Remember, *M* activities are produced under monopolistic competition, while *C* activities are competitive so there are no internal scale economies. Market Services are, broadly, provided by numerous small firms producing differentiated services in which there are often appreciable internal scale economies, perhaps due fixed costs associated with the business start-up and the small equilibrium size of such firms. With a sole input of labour and each firm's total cost function linear, so that $L = s + am(t)$ with fixed labour requirement *s* and marginal labour requirement *a* for typical firm or variety *t*, then as the equilibrium output $m(t)$ increases, returns to scale (defined as average cost divided by marginal cost) will fall asymptotically to 1. Hence it seems reasonable to choose a sector typified by small firms using labour as a predominant input. Firms freely enter and leave the market, with competitive pressure giving a zero profit equilibrium, and this also seems to describe the behaviour of many market services firms. In contrast I assume that all other sectors, including Manufacturing, are competitive with constant returns to scale. Similar assumptions that Market Services can be characterized as monopolistically competitive are made by Rivera-Batiz(1988) and Abdel-Rahman and Fujita(1990), among others.

The theory developed by Fujita, Krugman and Venables (1999) is written in terms of two regions, but the implication is that it applies to R regions. To achieve this, we assume iceberg transport costs of the form $\overline{T}_{ir} = e^{\tau \ln D_{ir}}$, in which D_{ir} is the distance[3] between regions i and r, using the often-used convention (Head and Mayer, 2003) that $D_{ii} = \frac{2}{3}\sqrt{\frac{area}{\pi}}$ in which *area* is the areas area in square miles[4]. For ease of calculation we assume that $\tau = 0.1$, so as to avoid large values in the exponentiation. The natural logarithm of distance is used because empirical studies almost invariably show that

[2] Assuming that *M* activities are equivalent to Manufacturing, while all other sectors ('agriculture') are *C* activities, follows Fujita, Krugman and Venables (1999). Manufacturing is assumed to have increasing returns to scale in many theoretical and applied papers, for example Forslid et. al. (2002) use evidence from the presence of scale economies in different industrial sectors provided by Pratten (1988).

[3] These are simply straight-line distances in miles, since it is considered unnecessary to use great circle distances within a small area such as Great Britain.

[4] The assumption is that each area is circular and that within-area distances equal the mean distance from the centre to uniformly distributed points within the circle.

this produces a better fit in gravity models that distance per se. Note that this implies a power function, since $(e^{\tau \ln D_{ir}})^{\beta} = e^{\beta\tau \ln D_{ir}} = D_{ir}^{\tau\beta}$.

Measuring market potential

The right hand side of equation (1) within brackets can be referred to as the level of market access or market potential *P*. If for simplicity we assume a nominal market potential measure in the spirit of Harris(1954), so that prices are constant across regions, wage levels will be high in regions with low transport costs to high income regions, while isolated regions will tend to have low wage levels. Allowing price variation gives us real market potential but adds a complication, with high prices (low competition) raising wages, and low prices (strong competition) lowering wages. The price index decreases in the number of varieties, so competition effects will be stronger in larger (more varied) regions.

Unfortunately, we do not have data for *M* wage rates, but only for the overall wage rate[5] w_i^o in each UALAD, as described by Figure 1. We therefore use the overall wage rate as a proxy for w_i^M and include an error term in our model to capture this measurement error. This also means that measurement error is incorporated into the market potential P_i, which depends on w_i^M . Also we do not know the value of σ , so we use a value in constructing G_i^M and P_i^M that is similar to the values for elasticity of substitution in the published literature. Hence we assume that $\sigma = 6.25$ (the mid-point of the published range given by Head and Mayer, 2003). Partly because of the measurement errors, we use an instrument for P_i^M as part of a 2sls estimation routine (see below).

[5] The observed wages are taken from the year 2001 results of the Office for National Statistics' New Earnings Survey, which is carried out annually by the UK's Office of National Statistics. These are workplace based survey data of gross weekly pay for male and female full time workers irrespective of occupation, so are not directly comparable with the *C* wages and *M* wages produced by the model. These are available on the NOMIS website (the Office for National Statistics' on-line labour market statistics database). There are no data for Scilly isles, so the data for the nearest mainland area of Penwith have been used in this case. These data are normalised so that w^o = wage/mean(wage).

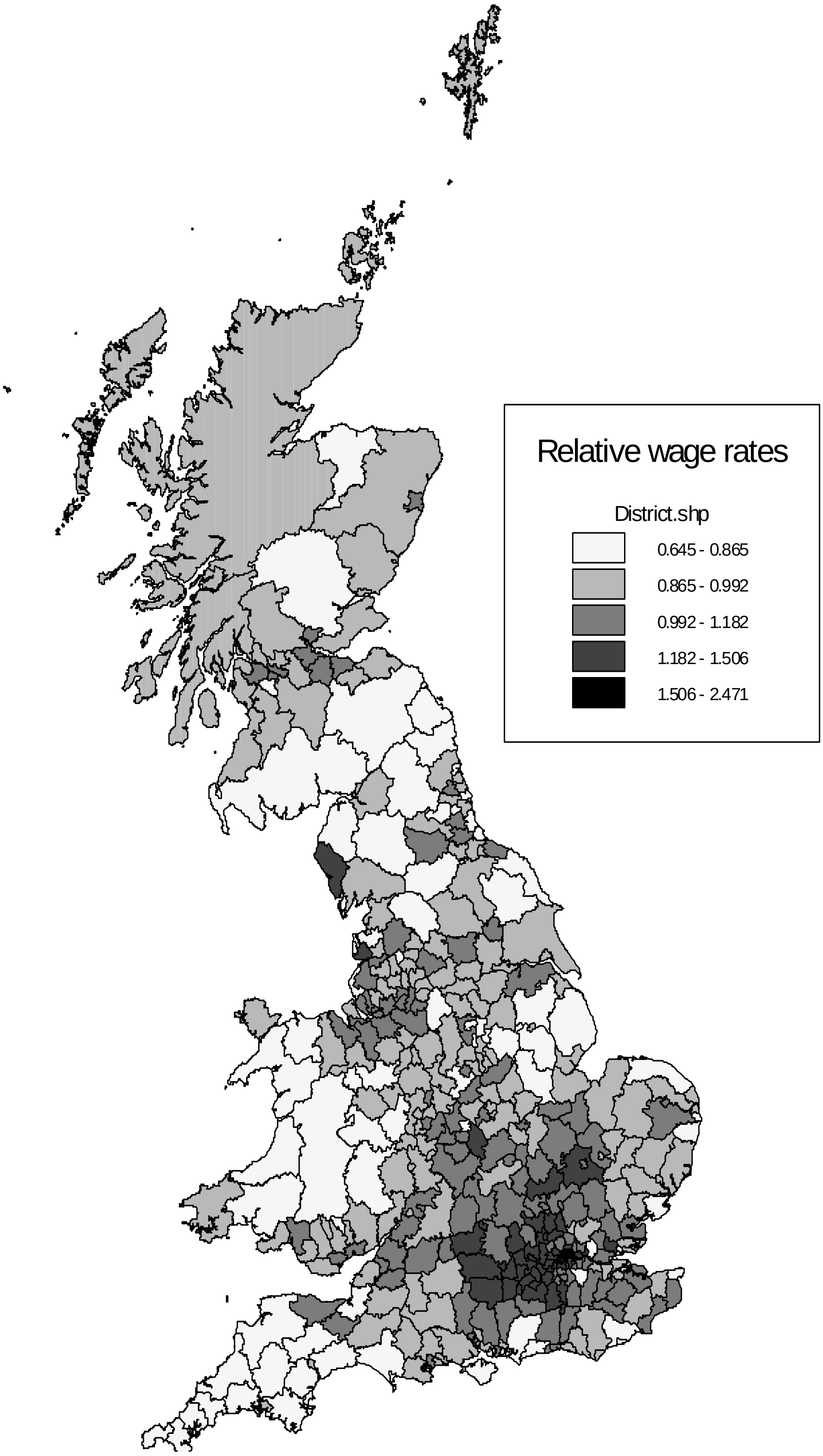

Figure 1: Wage rates (relative to the mean)

An integral part of P_i is the price index G_i. Following Fujita, Krugman and Venables (1999), and using the assumed distance impedance function in a multiregional setting, the M price index is

$$G_i^M = [\sum_r \lambda_r (w_r^M e^{\tau \ln D_{ir}})^{1-\sigma}]^{\frac{1}{1-\sigma}} \tag{2}$$

in which the number of varieties produced in region r is represented by λ_r, which is equal to the share in region r of the total supply of *M* workers. This gives values for G_i^M which are plausible, with low prices in highly competitive areas such as Central London, and higher prices in remote areas. For example, the ratio of the *M* price indices for the areas in Central London and the Shetland Islands is about 1.22, while prices are 8% higher in mid-Devon, and 1% higher in inner Manchester. Figure 2 gives the relative price indices. These assumptions underpin the empirical estimates of market access described below.

Given G_i^M one can obtain the market potential P_i^M, and therefore test the wage equation $w_i^M = (P_i^M)^{\sigma^{-1}} = [\sum_r Y_r (G_r^M)^{\sigma-1}(e^{\tau \ln D_{ir}})^{1-\sigma}]^{\frac{1}{\sigma}}$. One of the system of equations in Fujita, Krugman and Venables(999) is the expression for income, which is

$$Y_r = \theta\lambda_r w_r^M + (1-\theta)\phi_r w_r^C \qquad (3)$$

In order to estimate equation (3), we use the share of C workers[6] in each region (ϕ_i), and the share of *M* workers (λ_r), and the expenditure share of *M* goods (θ) is taken as the overall share of total employment in 2000 that is engaged in *M* activities, assuming also that θ is also the total *M* workers and 1-θ is the total *C* workers using a suitable metric that equates the overall number of workers to 1. Again we use the proxy w_i^o for w_i^M and we assume that $w^C = MEAN(w_r^o)$, which also produces plausible measures of the relative incomes and therefore real market potentials (see Figure 3). This approach to *P* estimation differs from gravity model based estimates that make use of trade flows (for example Redding and Venables[7], 2004).

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[6] Employment levels are given by the annual business enquiry employee analysis, also carried out by the Office of National Statistics and available on the NOMIS database.

[7] Redding and Venables(2004) focus on the equivalent to the wage equation in an international setting using a related but different theoretical set up to the one underpinning this paper. In their model, wages are a function of market access and access to suppliers of intermediate goods, and they measure market (and supplier) access via an auxiliary gravity model fitted to international trade data.

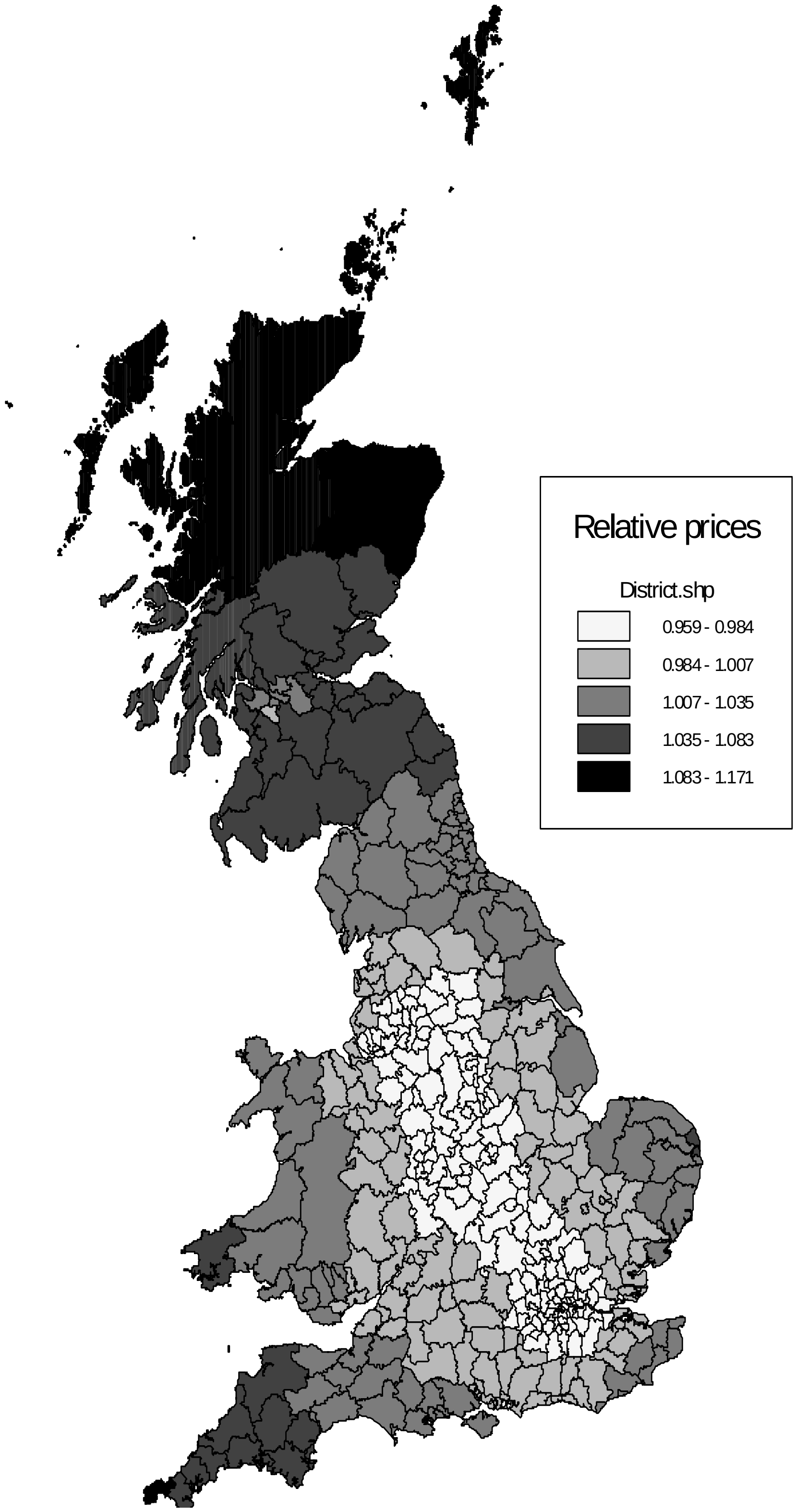

Figure 2: M prices (relative to the mean)

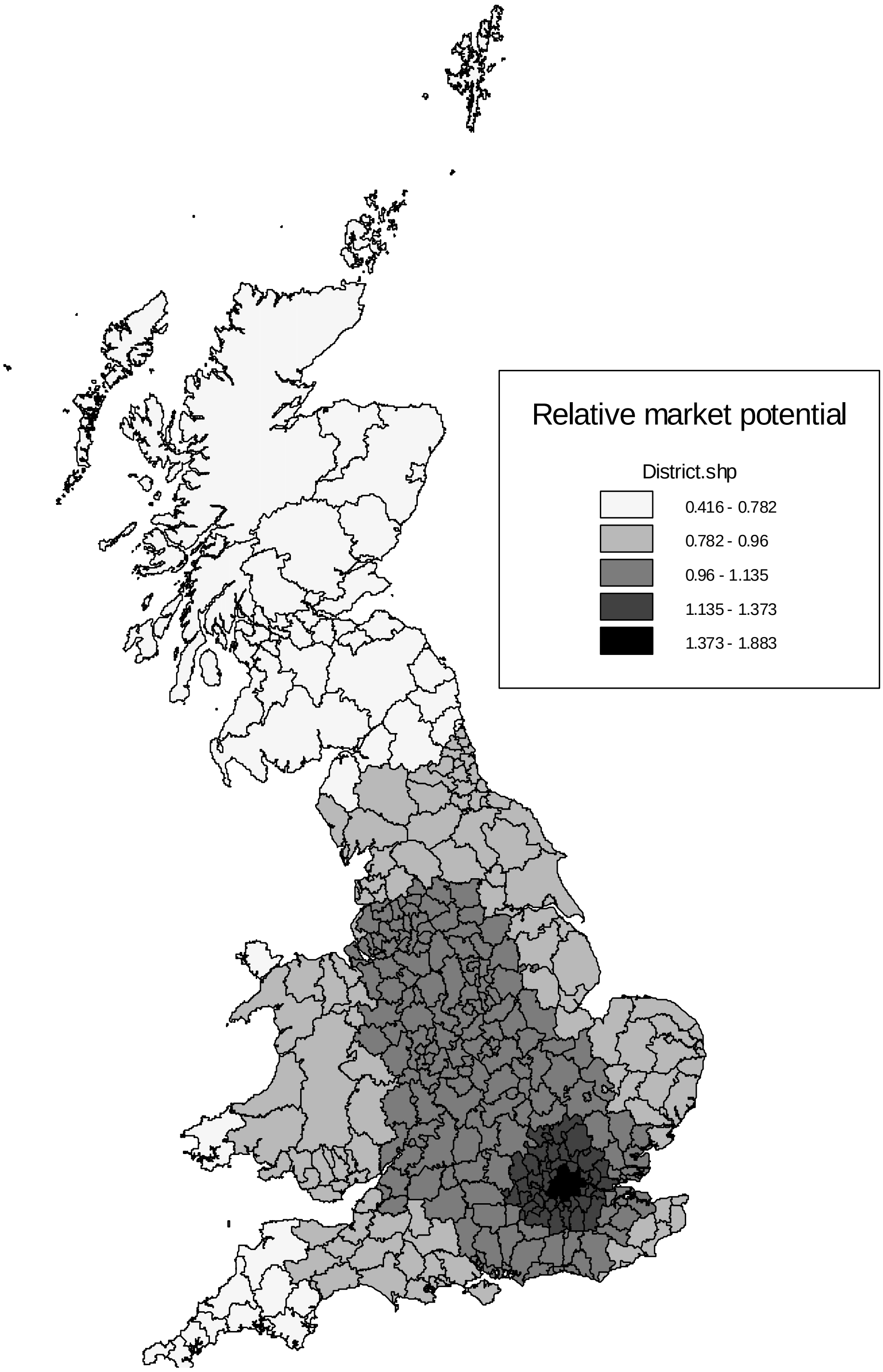

Figure 3: Real market potential (relative to the mean)

Unfortunately trade flows are not available at the level of spatial resolution adopted here.

Introducing efficiency variations

There are factors other than market potential that we assume will also cause w_i^M and w_i^o to vary relating to the level of efficiency of workers (A_i) in each local area. Given that we are analysing small area data within the UK, we assume that that the key determinant of the variation in efficiency level among areas is differences between workers in their ability to make use of the technology that is available. We therefore assume that technology is homogeneous across the areas but differences exist between areas in terms of the ability to apply that technology in production. As a first approximation, we therefore assume that efficiency depends on local levels of schooling (*S*) and on workplace acquired skills (*T*).

Introducing these extra variables contradicts somewhat the theory underlying the NEG wage equation which is based on the existence of pecuniary externalities, while other effects are excluded from the formal structural model. However in the real world a range of other factors will also play a part in determining observed wage rates, and excluding them would severely bias our estimates, as will be shown below. In fact we are making a shift in the definition normally applied in NEG theory, which in its basic form (Fujita, Krugman and Venables, 1999) does not distinguish between efficiency wages (earnings per efficiency unit) and earnings per worker. In other words, we are extending the wage equation by writing

$$\begin{aligned} \tilde{w}_i^M &= \frac{\overline{W}_i^M}{E_i^M A_i} = P_i^{\frac{1}{\sigma}} \\ w_i^M &= \frac{\overline{W}_i^M}{E_i^M} = P_i^{\frac{1}{\sigma}} A_i \end{aligned} \tag{4}$$

Recognising this distinction opens the door to our additional variables.

The variable *S* (Figure 4) is the percentage of residents with no qualifications given[8] by the UK's 2001 Census. The rationale for this variable is the widely recognised link between labour inefficiency and inadequate schooling. The focus is no qualifications, since this is considered to be a more transparent measure than the various levels of qualification indicators that are also available, eliminating the problem of determining which level of schooling one should focus on, maintaining the same intrinsic meaning across cultures and time, and being an important focus for policy initiatives. The technical 'workplace oriented' knowledge (*T*) of the workforce is approximated by the relative concentration of employees in the computing and research and

[8] Available from the website Casweb, which is a web interface to statistics and related information from the United Kingdom Census of Population.

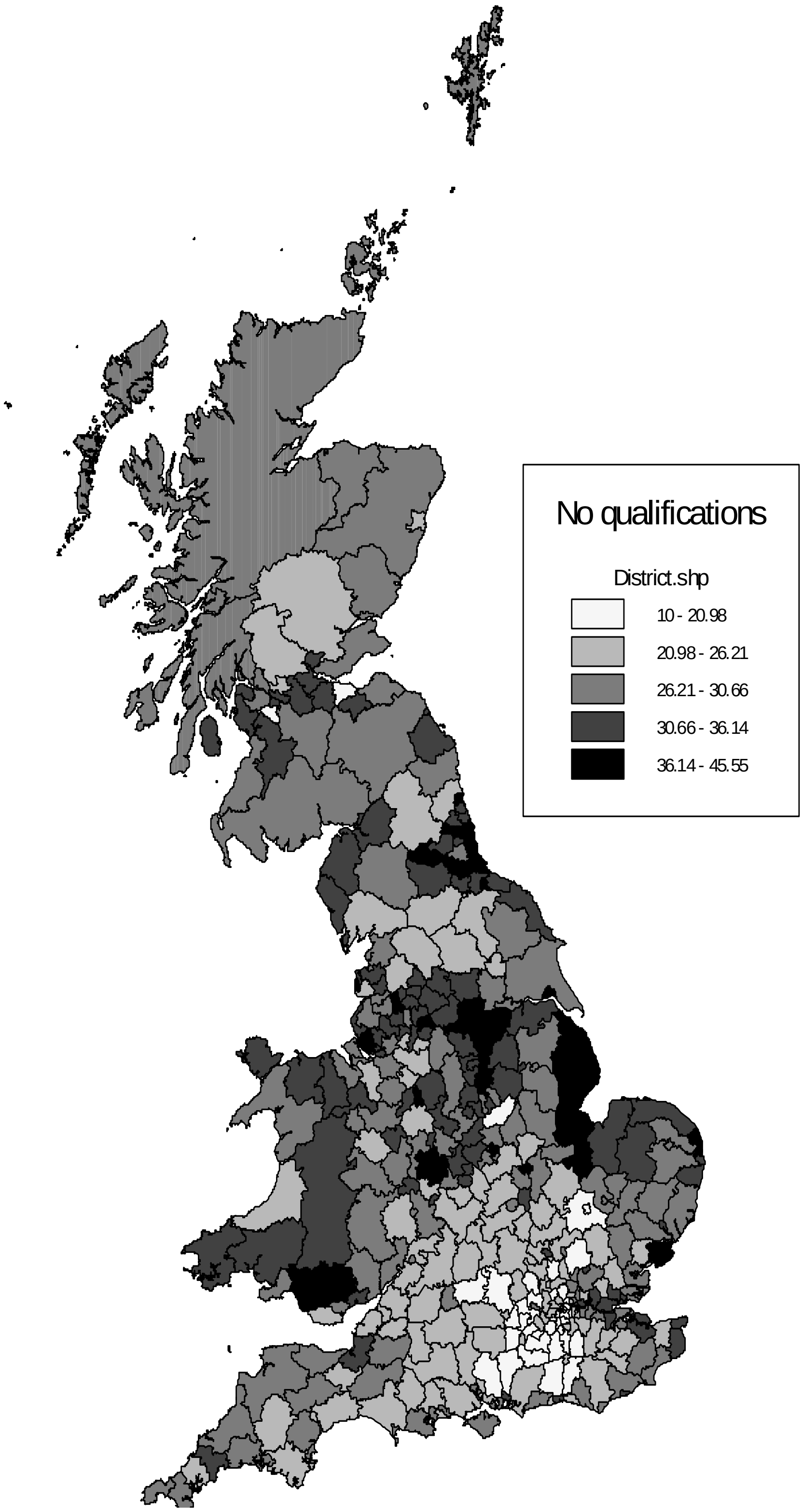

Figure 4: Percent of residents with no qualifications

development sectors. Therefore T is the location quotient for each area (Figure 5) giving the workforce specialisation in computing and related activities (1992 SIC 72) and in research and development (1992 SIC 73), calculated from data taken from the

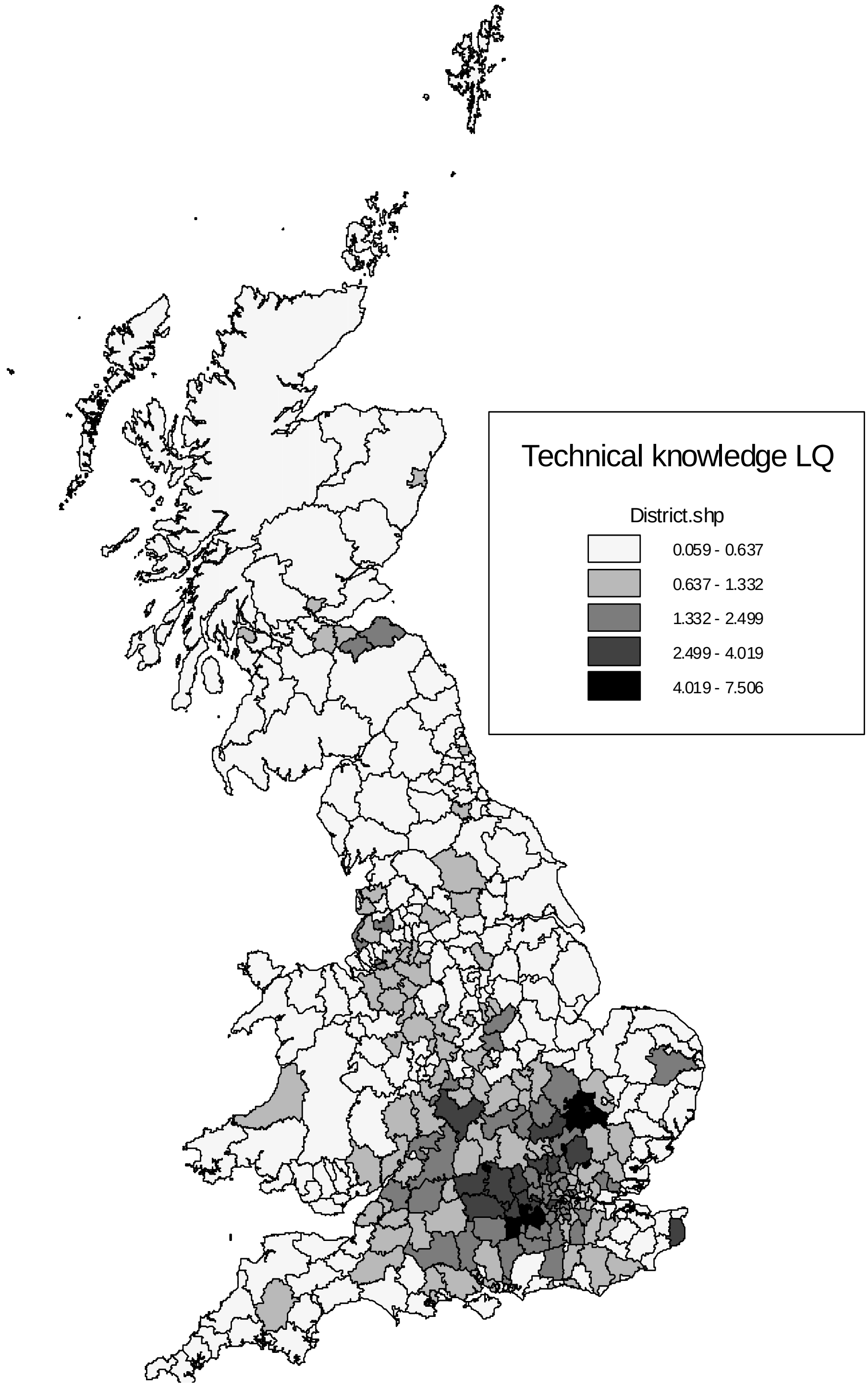

Figure 5: Technical knowledge LQ

annual business enquiry employee analysis (available through NOMIS).[9] This therefore measures the relative concentration by area of employees with work-related skills in hardware consultancy, software consultancy and supply, data processing, data base activities, computer and office machinery maintenance and repair, and in other unspecified computer related activities. In addition it includes workers involved in

[9] The location quotient is the share of local employment in these sectors divided by national share.

research in the natural sciences and engineering, and in the social sciences and humanities.

Introducing commuting

The wage data are based on employer surveys and therefore relate to the place of work not the place of residence. This means that we have to take account of the effect of commuting, since labour efficiency within an area is also a function of the efficiency level in other areas from which workers commute. This gives the specification for an area's efficiency level as

$$\ln(A) = b_0 + b_1 S + b_2 T + \rho W \ln(A) + \xi \qquad (5)$$

in which the term $W\ln(A)$ represents the contribution to efficiency due to commuting, as defined by the matrix *W*. This term is the matrix product of the so-called *W* matrix and ln (*A*), where the definition of *W* is

$$\begin{aligned} W_{ir} &= \exp(-\delta_i D_{ir}) \qquad i \neq r \\ W_{ir} &= 0 \qquad i = r \\ W_{ir} &= 0 \qquad D_{ir} > 100km \end{aligned}$$

This shows that the value allotted to cell (i, r) of the *W* matrix is a function of the (straight line) distance (D_{ij}) between areas and an exponent δ_i that reflects the area-specific distance decay. The choice of exponent δ_i is based on empirical comparisons with observed census data on travel to work patterns[10], following the calibration method given in Fingleton(2003).

The estimating equations

Combining equations(4) and (5), it can be shown (see Appendix) that

$$\ln w^o = \rho W \ln w^o + a_1(\ln P - \rho W \ln P) + b_0 + b_1 S + b_2 T + \xi + (I - \rho W)\omega \qquad (6)$$

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[10] 1991 Census of Population - Special Workplace Statistics, available from NOMIS.

This equation has some special features that should be noted for estimation purposes. First it contains an endogenous lag $W \ln w^o$ and the variable P which is subject to both measurement error and is endogenous because it depends on w^o. Secondly there is the parameter constraint involving ρ. Third it contains an autoregressive error structure involving ω. We therefore use iterative 2sls to estimate the equation, with each iteration giving an updated ρ from the $W \ln w^o$ term which is then used to update $\rho W \ln P$ and $\ln P - \rho W \ln P$ for the subsequent iteration, until ρ reaches a steady state, as in Fingleton and McCombie(1998) and Fingleton(2003). The endogenous right hand side terms $W \ln w^o$ and $\ln P - \rho W \ln P$ are replaced in each iteration by instruments equal to the fitted values of first stage regressions. In the case of $W \ln w^o$ the regressors are the instrumental variable I^P, as explained below, and the exogenous and lagged exogenous variables (ie *S, T, WS, WT*)[11]. Likewise for $\ln P - \rho W \ln P$ we use the same regressors I^P, *S, T, WS,* and *WT*. Note that since $\ln P - \rho W \ln P$ changes in each iteration, so in principle does I^P. We have disregarded the autoregressive errors in the model, but we test for residual autocorrelation in the model to check whether this leads to any specification error.
With regard to the instrumental variable I^P, the method used is based on the 3 group method (described in Kennedy, 1992, and Johnston, 1984) in which I^P takes values 1, 0 or -1 according to whether $\ln P - \rho W \ln P$ is in the top, middle or bottom third of its ranking, which ranged from 1 up to 408.[12]

Because of the complexity of the estimation method, throughout we also choose to give the results of a simpler method in which there is no commuting effect, simply to highlight its necessity. The estimating equation in this case is as above but with ρ set to zero, hence

$$\ln w^o = +a_1 \ln P + b_0 + b_1 S + b_2 T + \xi \qquad (7)$$

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[11] *S*ee Kelejian and Robinson (1993), Kelejian and Prucha (1998) for a discussion of the efficacy of the use of low order spatial lags. While the use of spatial lags is seen as an effective way to generate instruments, these authors warn against including high order spatial lags to avoid linear dependence.

[12] This method is described in the context of variables subject to measurement error, but is intended here to have the same effect of eliminating correlation between the instrument and the error term.

In this case there is obviously no need for iterative 2sls, so estimation is 2sls to allow for the endogeneity and measurement error in *P*, using simply I^P in the first stage regression, where in this case this –1,0,1 variable is from the ranking of ln *P*.

As mentioned above, for both iterative 2sls and 2sls, since we do not know the value of σ, we assume $\sigma = 6.25$ in constructing G_i^M and P_i^M hoping that the estimated $\hat{\sigma}$ obtained from the regression equations is not too dissimilar. The first indication of whether this is indeed the case is given by the 2sls (no commuting) estimates in columns 2 and 3 of Table 1.

Table 1 NEG model estimates

Parameter	**No commuting 2sls estimate (st. error)**	**t ratio**	**Commuting 2sls estimate (st. error)**	**t ratio**
constant (a_0)	0.027594 (0.035358)	0.78	-0.109058 (0.029895)	-3.65
spillover $W\ln(w)$ (ρ)			0.001389 (0.000110)	12.68
market access P_i ($1/\sigma$)	0.372136 (0.037622)	9.89	0.112977 (0.044051)	2.56
schooling S_i (a_1)	-0.004941 (0.001088)	-4.54	-0.001155 (0.000914)	-1.26
technical knowledge T_i (a_2)	0.050119 (0.007398)	6.77	0.050297 (0.006040)	8.33
error variance (Ω^2)	0.01300		0.008435	
R-squared*	0.5464		0.7148	
Correlation[1]	0.5506		0.7090	
Degrees of freedom	404	403		
Residual autocorrelation[2] (z)	11.03	1.482		

note:
*. Given by Var($\hat{Y}$)/Var(*Y*), where *Y* is the dependent variable.
1. The square of the Person product moment correlation between observed and fitted values of the dependent variable.
2. The Anselin and Kelejian (1997) test for residual correlation with endogenous variables either with or without endogenous lag, using the commuting matrix.

This gives $\hat{\sigma}$ = 2.687 with approximate 90% confidence interval of 2.31 to 3.22 which excludes σ = 6.25. However this is a biased estimate. This is apparent from the presence of autocorrelated residuals. The appropriate test is the test for residual spatial autocorrelation with endogenous variables (in this case P) but no spatial lag, given by Anselin and Kelejian (1997). The test statistic is equal to 11.03 which is clearly an extreme value in the N(0,1) reference distribution, indicating the presence of significantly spatially autocorrelated residuals.

We next proceed by allowing also for the fact that an area's worker efficiency also depends on commuting by estimating equation (6). Table 1 columns 4 and 5 show that P_i is significant allowing for the very strong effect due to commuting, with $\hat{\sigma}$ = 8.85. The approximate 90% confidence interval for $\hat{\sigma}$ is 5.40 to 24.55, which includes the assumed value used to construct P_i . Note that this specification eliminates significant residual autocorrelation. It appears that NEG-based theory provides a credible explanation of wage variation.

The role of producer service linkages

The UE-based model is derived in a similar way to that outlined above, with labour efficiency in each area dependent on the same suite of variables, so that equation (5) still applies. However, the core of the theory is that the monopolistically competitive service sector provides inputs to the production (Q) of competitive industry, in other words $Q = ((E^C A)^\beta I^{1-\beta})^\alpha$, in which $E^C A$ is the number of C labour efficiency units, and I is the level of composite services based on a CES production function for producer services under monopolistic competition. The presence of α indicates diminishing returns due to congestion effects (Ciccone and Hall, 1996), so that the variables are measured per unit of land. Since I depends only on $E^M A$ and $N = A(E^C + E^M)$, it is possible to show[13] that $Q = ((E^C A)^\beta I^{1-\beta})^\alpha = \phi N^\gamma$ with constants ϕ and $\gamma = \alpha[1 + (1-\beta)(\mu - 1)]$ where $\frac{\mu}{\mu - 1}$ is the elasticity of substitution for different

[13] See for example Fingleton and López-Bazo (2003)

services. So long as $\gamma > 1$ this indicates that there are increasing returns with employment density. It follows, using standard equilibrium theory giving the equilibrium allocation of labour efficiency units to final production Q so that $\frac{w^o N}{Q} = \alpha$ (see Appendix and Fingleton, 2003), that this results in a wage equation thus

$$w^o = \rho W \ln w^o + (I - \rho W)\ln(\phi + \alpha) + (\gamma - 1)(\ln E - \rho W \ln E) + c_0 + c_1 S + c_2 T + \Psi \quad (8)$$

in which $E = E^C + E^M$ is the employment level per sq. km (see Figure 6).

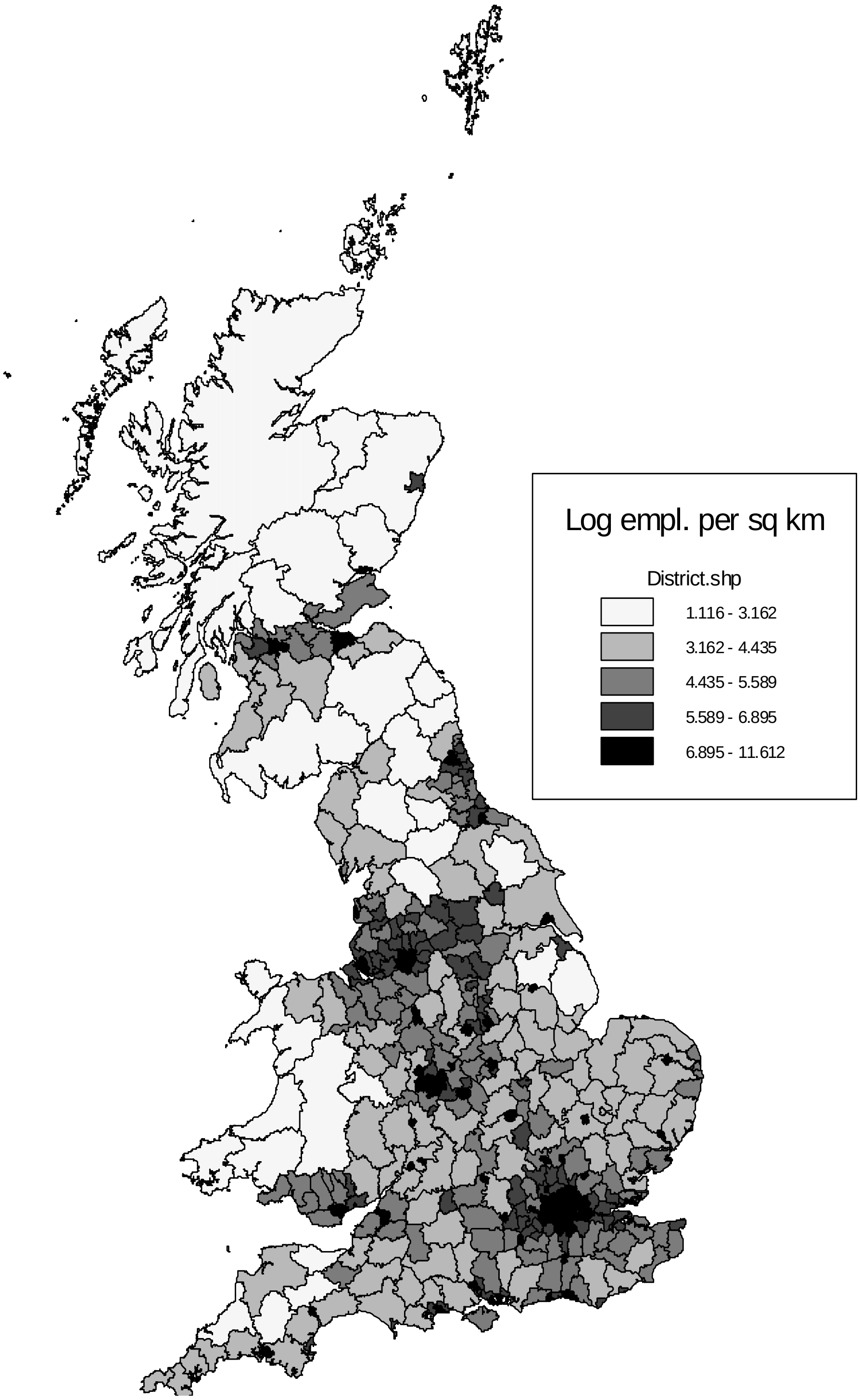

Figure 6 : Employment density

Unfortunately, we do not know α and ϕ so these are omitted from the estimating equation, which is therefore

$$w^o = \rho W \ln w^o + (\gamma - 1)(\ln E - \rho W \ln E) + c_0 + c_1 S + c_2 T + \Psi \qquad (9)$$

However the test for residual spatial autocorrelation below shows that this omission is evidently not a problem. Estimation of equation (9) presents the same problems as equation (6), since we have an endogenous variable E (employment density will depend on wage rates), an endogenous spatial lag $W \ln w^o$, a constraint involving ρ, and an omitted variable. The method of estimation is again iterative 2sls, which is carried out in precisely the same way as for the NEG model, except that among the set of regressors for the first stage 2sls regressions of each iteration, I^P is replaced by I^E, which is the –1,0,1 variable from the ranking in each iteration of $(\ln E - \rho W \ln E)$.

Again we set an alternative set of estimates alongside the iterative 2sls estimates, based on the estimating equation (10) in which the effect of commuting is nullified, hence with ρ = 0 in equation (9), we obtain

$$w^o = (\gamma - 1)\ln E + c_0 + c_1 S + c_2 T + \Psi \qquad (10)$$

In this case the method used is 2sls with the single first stage regressor a –1,0,1 variable using the ranking of ln E. The estimates given in Table 2 columns 2 and 3 show that the no-commuting version of the UE model is also misspecified, as shown by the significant residual spatial autocorrelation. In the full version of the model (columns 4 and 5) there is no evidence of residual spatial autocorrelation. The model shows that there are significant increasing returns to employment density, and that the level of fit mirrors that of the NEG model. .

Table 2 UE model estimates

Parameter	No commuting 2sls estimate (st. error)	t ratio	Commuting 2sls estimate (st. error)	t ratio
constant (c_0)	-0.071712 (0.037755)	-1.90	-0.153489 (0.030334)	-5.06
spillover $W\ln(w)$ (ρ)			0.001422 (0.000087)	16.40
service inputs E_i $(\gamma - 1)$	0.039727 (0.003985)	9.97	0.013978 (0.003845)	3.64
schooling S_i (c_1)	-0.007407 (0.001098)	-6.75	-0.001751 (0.000921)	-1.90
technical knowledge T_i (c_2)	0.062147 (0.006944)	8.95	0.052693 (0.005489)	9.60
error variance (Σ^2)	0.01293		0.008053	
R-squared	0.5285		0.7175	
Correlation[1]	0.5533		0.7222	
Degrees of freedom	404		403	
Residual autocorrelation[2] (z)	19.64		1.331	

Tests of non-nested hypotheses

In this section I try to come to a decision about whether it is possibly to falsify one, both or neither of the two competing theories. The problem with this assessment is that here we are dealing with non-nested hypotheses, H0: NEG and H1: UE. By non-nested I mean that the explanatory variables of one are not a subset of the explanatory variables of the other, with the hypotheses representing conflicting theories and the standard inferential tool-kit which is available for nested hypotheses inapplicable. For example, in the context of likelihoods, if H0 is nested in H1, so that the two are identical apart from restrictions placed on one or more parameters under H0, then it is well known that the twice the difference in log likelihoods is distributed as χ_k^2 under the null that H0 is true, where k is the number of restricted parameters. With non-nested models this asymptotic distributional theory breaks down, leading to the work of Cox(1961,1962) and subsequently Pesaran(1974) and Pesaran and Deaton(1978) who considered the appropriate null distribution.

I first shed light on the issue by estimating a comprehensive model in which both hypotheses are embedded. I subsequently retain the theoretical distinction between the two by carrying out a so-called J-test. In these tests we naturally encounter the problems of inference that are endemic in the evaluation of non-nested hypotheses, but nevertheless the conclusions are surprisingly clear-cut.

A comprehensive model

In the NEG model, we have already strayed some way from theoretical purity by including some determinants of labour efficiency which are outside the mainstream model. These however help produce plausible estimates for σ. Consider now the following comprehensive model, that wage rates depend not only on market potential and labour efficiency, but also on the market services input linkages (density of employment E_i) in an area. The relation between wages and density is of course the basic reduced form from the UE theory, so one might wish to revisit NEG theory by allowing also producer service linkages in the spirit of de Vaal and van den Berg (1999). Therefore combining the effects of market potential, input linkages (employment density) and labour efficiency, following the same arguments as earlier (see Appendix), the resulting specification is

$$\ln w^o = \rho W \ln w^o + d_0[(I-\rho W)\ln E] + d_1[(I-\rho W)\ln P] + g_0 + g_1 S + g_2 T + \zeta \quad (11)$$

We can view this as an extended NEG model, but with wages also responding to supply-side variations in the variety of producer service inputs. Alternatively, we might consider this to be an extended version of UE theory, but with the added variable P_i represented varying demand due to market potential differences between localities.

Estimation proceeds exactly in the same way as for the NEG and UE models per se, by means of iterative 2sls until successive ρ estimates reach a steady-state, and with instrumental variables I^E, *S, WS, T, WT* for $(I-\rho W)\ln E$, I^P, *S, WS, T, WT* for $(I-\rho W)\ln P$, and I^E,I^P, *S, WS, T, WT* for $\rho W \ln w^o$.

Again, for purposes of comparison, we also eliminate commuting effects by restricting ρ to 0, so that in this case the estimating equation is

$$\ln w^o = +d_0 \ln E + d_1 \ln P + g_0 + g_1 S + g_2 T + \zeta \qquad (12)$$

The resulting estimates of this restricted model are given in columns 2 and 3 of Table 3, and these suggest that wage rates are dependent both of market potential and on producer service inputs. However this model is misspecified, as shown by the very significant residual spatial autocorrelation, and when we eliminate this by introducing commuting effects, it is apparent that market potential is barely significant using conventional Type I error rates, with a one-tailed p-value equal to about 0.04. This begs the question, is there evidence here to falsify NEG ? We would find support for the H0: NEG by failing to reject H0: d_1 =0. Likewise we would find support for the H1: UE by failing to reject H0: d_0 =0. In fact we do find support for H1 but there is lack of support for H0. On the face of it this is quite a remarkable conclusion, given that NEG theory has become increasingly popular in recent years, and we therefore need to be very cautious in our interpretation of the data given that the results here stand opposed to the theory and empirical analysis of numerous studies. In order to exercise this caution, we carry out some further tests of these competing theories.

Table 3 Comprehensive model estimates

Parameter	No commuting 2sls estimate (st. error)	t ratio	Commuting 2sls estimate (st. error)	t ratio
constant (g_0)	-0.061379 (0.035815)	-1.71	-0.142041 (0.031125)	-4.56
spillover $W\ln(w)$ (ρ)			0.001297 (0.000112)	11.61
market access P_i (d_0)	0.264936 (0.038796)	6.83	0.077787 (0.044524)	1.75
service inputs E_i (d_1)	0.028476 (0.004121)	6.91	0.012335 (0.003984)	3.10
schooling S_i (g_1)	-0.006422 (0.001051)	-6.11	-0.001891 (0.000927)	-2.04
technical knowledge T_i (g_2)	0.045330 (0.007027)	6.45	0.048780 (0.005936)	8.22
error variance (κ^2)	0.01161		0.008089	
R-squared	0.6447		0.7243	
Correlation[1]	0.6003		0.7216	
Degrees of freedom	403		402	
Residual autocorrelation[2] (z)	3.972		1.397	

Some further non-nested tests

The approach use here is the Davidson and McKinnon(1981,1982) J-test applied to 2sls estimation. Pioneers in the use of non-nested tests with spatial data include Paelinck and Klaassen(1979) and Anselin(1988), who gives the necessary conditions[14] and evaluates their practical relevance for spatial analysis. With the presence of an endogenous spatial lag, Cox-type tests resulting from the comparison of likelihoods are fairly impracticable because of the absence of simple analytical derivations, unlike Pesaran(1974) and Walker(1967) who worked in the context of serial correlation. The J-test is much more straightforward, and can easily extend from ML to 2sls as employed here.

[14] Anselin(1986) show that the asymptotic properties required for the J test hold with spatial models with lagged dependent variables, provided that the model has a bounded variance and spatial dependence decays with distance, conditions which are satisfied here and in most applications.

The situation is that H0: NEG and H1: UE, so we simply estimate the H1 model to obtain fitted values, which are then added as an auxiliary variable to the H0 model. If the coefficient on the added variable is not significantly different from 0, testing in the asymptotic N(0, 1) distribution, then we do not reject H0. However, we also need to test the opposite case, since the non-symmetry of the test means that rejecting H0 in no way implies that H1 is true, and vice versa. It could turn out that both H0 and H1 are falsified. Consequently there are two specifications to consider, the first which applies when NEG is the maintained hypothesis, is simply an extension[15] of equation (6), hence

$$\ln w^o = \rho W \ln w^o + a_1(\ln P - \rho W \ln P) + b_0 + b_1 S + b_2 T + b_3 \hat{w}^o + \xi \qquad (13)$$

in which the auxiliary variable $\hat{w}_i^o$ is the vector of fitted values under H1: UE. The fitting of both the H0 and H1 models is via iterative 2sls carried out in exactly the same way as previously, except that for H0, there is an additional instrument ($\hat{w}_i^o$). Also we create a non-commuting version by again restricting ρ to 0, with estimation and instrumentation precisely as before. Table 4 gives the results, and since the auxiliary variable under both specifications is significant, there is evidence here to reject the maintained hypothesis H0:NEG. Allowing for commuting, the usual test shows no residual autocorrelation.

[15] Again omitting $(I - \rho W)\omega$

Table 4 (Iterative) 2sls estimates with NEG as maintained hypothesis

Parameter	No commuting 2sls estimate (st. error)	t ratio	Commuting 2sls estimate (st. error)	t ratio
constant (b_0)	-0.009977 (0.035317)	-0.28	0.019650 (0.042005)	0.47
spillover $W\ln(w)$ (ρ)			-0.000300 (0.000409)	-0.73
market access P_i ($a_1 = 1/\sigma$)	0.264936 (0.040466)	6.55	0.057905 (0.044358)	1.31
schooling S_i (b_1)	-0.001113 (0.001218)	-0.91	-0.000096 (0.000924)	-0.10
technical knowledge T_i (b_2)	0.000784 (0.010423)	0.08	-0.009905 (0.015253)	-0.65
$\hat{w}_i^o$ (b_3)	0.716795 (0.108186)	6.63	1.117113 (0.259962)	4.30
error variance ($\bar{\psi}^2$)	0.01263		0.008053	
R-squared	0.5840		0.7276	
Correlation[1]	0.5644		0.7229	
Degrees of freedom	403		402	
Residual autocorrelation[2] (z)	7.249		1.317	

If we reverse the situation with H1:UE now the maintained hypothesis, the estimating equation is the augmented version[16] of equation (9),

$$w^o = \rho W \ln w^o + (\gamma - 1)(\ln E - \rho W \ln E) + c_0 + c_1 S + c_2 T + c_3 \hat{w}^o + \Psi \qquad (14)$$

in which $\hat{w}_i^o$ is now the vector of fitted values from H0. Again the usual iterative 2sls estimation routine is used, but with $\hat{w}_i^o$ again entering as an extra instrument. The noteworthy conclusion from this analysis is that it fails to falsify the maintained hypothesis. It is apparent that UE alone can explain the observed variation in wage levels, and that NEG does not have any additional explanatory power, although this outcome depends on eliminating error autocorrelation (due essentially to commuting).

[16] Again omitting $(I - \rho W)\ln(\phi + \alpha)$.

However as mentioned above we should be careful in interpreting non-nested hypothesis testing methods, since there is a problem in comparing two conditional distributions under different conditioning variables. In our tests including $\hat{w}_i^o$ invalidates standard statistical theory since $\hat{w}_i^o$ is an artificial variable constructed from, and therefore not independent of, the dependent variable w_i^o. The normal asymptotic reference distribution can fail to be appropriate, as borne out by simulation studies that indicate that the true p-value is larger than suggested by the normal approximation. This however means that using the normal approximation will tend to reject the true model too frequently, adding further weight to the interpretation that UE is 'true'. With regard to NEG as the maintained hypothesis, the extreme significance of $\hat{w}_i^o$ under the normal approximation suggests that it should nonetheless be rejected, although we should be a bit more circumspect regarding this conclusion. There is an extensive literature (see for example the review by Szroeter, 1999) dedicated to the task of developing more user-friendly and reliable non-nested hypothesis tests, including the Mizon and Richards(1986) encompassing test, of which the J-test (variance encompassing) and the test based on the comprehensive model (mean encompassing) are special cases, although none are as straightforward as the J-test.

Table 5 (Iterative) 2sls estimates with UE as maintained hypothesis

Parameter	No commuting estimate (st. error)	No commuting t ratio	Commuting estimate (st. error)	Commuting t ratio
constant (c_0)	-0.081024 (0.037053)	-2.19	-0.104408 (0.049835)	-2.10
spillover $W\ln(w)$ (ρ)			0.000834 (0.000475)	1.76
service inputs E_i ($\gamma - 1$)	0.028476 (0.004264)	6.68	0.012334 (0.004088)	3.02
schooling S_i (c_1)	-0.002904 (0.001275)	-2.28	*-0.001341* (0.000978)	-1.37
technical knowledge T_i (c_2)	0.009649 (0.010472)	0.92	0.031841 (0.017623)	1.81
$\hat{w}_i^o$ (c_3)	0.711934 (0.107876)	6.60	0.376279 (0.302327)	1.24
error variance ($\overline{\Sigma}^2$)	0.01243		0.008065	
R-squared	0.5652		0.7190	
Correlation[1]	0.5712		0.7225	
Degrees of freedom	403		402	
Residual autocorrelation[2] (z)	13.54		1.259	

Conclusions

In this paper two non-nested hypotheses have been compared, one based on NEG theory and the well-known relation between wage rates and market potential, the other based on UE theory with wages dependent on producer services linkages. The empirical evidence favours UE theory. However there are a considerable number of caveat that should be introduced to provide a more rounded interpretation of our findings, relating to the inferential problems in testing non-nested hypotheses and the problem of measuring market potential, which depends on a suite of assumptions. Nevertheless, the paper shows that it is quite easy to produce evidence that NEG theory is a valid basis for the analysis of factor markets at this level of spatial resolution which actually does not stand up to detailed scrutiny. Despite the attractions of NEG theory, we should not expect it to work at all spatial scales. It appears that when we are dealing with small regions, what is more important are variations in an area's access to efficient labour, and the variety of producer services that are available. Differences in market potential appear to be of more limited relevance.

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Appendix

The labour efficiency submodel

$$\ln A = b_0 + b_1 S + b_2 T + \rho W \ln A + \xi$$
$$\xi \sim N(0, \Omega^2)$$
$$(I - \rho W)\ln A = b_0 + b_1 S + b_2 T + \xi$$
$$\ln A = (I - \rho W)^{-1}(b_0 + b_1 S + b_2 T + \xi)$$

Derivation of the NEG wage equation

$$\ln w^o = a_1 \ln P + \ln A + \omega$$
$$\omega \sim N(0, \Pi^2)$$
$$\ln w^o = a_1 \ln P + (I - \rho W)^{-1}(b_0 + b_1 S + b_2 T + \xi) + \omega$$
$$(I - \rho W)\ln w^o = (I - \rho W)(a_1 \ln P) + b_0 + b_1 S + b_2 T + \xi + (I - \rho W)\omega$$
$$\ln w^o = \rho W \ln w^o + (I - \rho W)(a_1 \ln P) + b_0 + b_1 S + b_2 T + \xi + (I - \rho W)\omega$$
$$\ln w^o = \rho W \ln w^o + a_1(\ln P - \rho W \ln P) + b_0 + b_1 S + b_2 T + \xi + (I - \rho W)\omega$$

Derivation of the UE wage equation

$$Q = ((E^C A)^\beta I^{1-\beta})^\alpha = \phi N^\gamma$$
$$E_i = E_i^C + E_i^M$$
$$N = EA$$
$$\frac{w^o EA}{Q} = \alpha$$
$$\ln w^o = \ln(\phi + \alpha) + (\gamma - 1)\ln E + (\gamma - 1)\ln A$$
$$\ln w^o = \ln(\phi + \alpha) + (\gamma - 1)\ln E + (\gamma - 1)(I - \rho W)^{-1}(b_0 + b_1 S + b_2 T + \xi)$$
$$\ln w^o = \rho W \ln w^o + (I - \rho W)\ln(\phi + \alpha) + (\gamma - 1)(I - \rho W)\ln E + (\gamma - 1)(b_0 + b_1 S + b_2 T + \xi)$$
$$\ln w^o = \rho W \ln w^o + (I - \rho W)\ln(\phi + \alpha) + (\gamma - 1)(I - \rho W)\ln E + c_0 + c_1 S + c_2 T + \Psi$$
$$\ln w^o = \rho W \ln w^o + (I - \rho W)\ln(\phi + \alpha) + (\gamma - 1)(\ln E - \rho W \ln E) + c_0 + c_1 S + c_2 T + \Psi$$
$$\Psi \sim N(0, \Sigma^2)$$

Derivation of the comprehensive model

$$\ln w^o = d_0 \ln E + d_1 \ln P + d_2 \ln A$$
$$\ln w^o = d_0 \ln E + d_1 \ln P + (I - \rho W)^{-1} d_2 (b_0 + b_1 S + b_2 T + \xi)$$
$$(I - \rho W)\ln w^o = (I - \rho W)(d_0 \ln E + d_1 \ln P) + g_0 + g_1 S + g_2 T + \zeta$$
$$\ln w^o = \rho W \ln w^o + (I - \rho W)(d_0 \ln E + d_1 \ln P) + g_0 + g_1 S + g_2 T + \zeta$$
$$\ln w^o = \rho W \ln w^o + (I - \rho W) d_0 \ln E + (I - \rho W)(d_1 \ln P) + g_0 + g_1 S + g_2 T + \zeta$$
$$\ln w^o = \rho W \ln w^o + d_0[(I - \rho W)\ln E] + d_1[(I - \rho W)\ln P] + g_0 + g_1 S + g_2 T + \zeta$$
$$\zeta \sim N(0, \kappa^2)$$

Appendix Table : Market Services subsectors defined as M activities

651 : Monetary intermediation
652 : Other financial intermediation
660 : Insurance and pension funding
671 : Activities auxiliary to financial intermediation
672 : Activities auxiliary to insurance/pension funding
701 : Real estate activities with own property
702 : Letting of own property
703 : Real estate activities
711 : Renting of automobiles
712 : Renting of other transport equipment
713 : Renting of other machinery and equipment
714 : Renting of personal/household goods nec
721 : Hardware consultancy
722 : Software consultancy and supply
723 : Data processing
724 : Data base activities
725 : Maintenance/repair office machinery etc
726 : Other computer related activities
731 : Research: natural sciences/engineering
732 : Research: social sciences/humanities
741 : Accounting/book-keeping activities etc
742 : Architectural/engineering activities etc
743 : Technical testing and analysis
744 : Advertising
745 : Labour recruitment etc
746 : Investigation and security activities
747 : Industrial cleaning
748 : Miscellaneous business activities nec