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Abstract
This report estimates housing-cost-earnings differentials across labour market areas in Britain. We show that quality-adjusted housing costs rise on average, one for one with the skill-adjusted earnings of the average working household. However, the relationship is U-shaped, with relatively high housing costs in places at the bottom and top ends of the wage distribution. This variation in housing costs means nominal wages are uninformative about real income disparities. If we assume spatial equilibrium and treat the cost-earnings differentials as estimates of the value of amenities, we can rank cities in terms of quality of life and estimate the value of different amenities. Our work improves on previous research by using longitudinal data on workers to estimate skill-adjusted labour market earnings differentials (net of taxes), using micro data on housing transactions, and by considering the implications of capital gains for housing user cost calculations.

Keywords: Britain, spatial equilibrium, labour market, housing market
JEL Classifications: J60, R23

1. Introduction

Earings disparities across areas in Britain are pronounced and very persistent (Gibbons, Overman and Pelkonen, 2010). These disparities between different areas give cause for concern, because they seem to imply differences in standards of living and economic welfare. It has long been recognised, however, that spatial earnings disparities are uninformative about such differences unless we take account of differences in the costs of living and the availability of local amenities (Rosen 1979; Roback, 1982). In this study, we consider the extent to which higher post-tax earnings are offset by higher housing costs across areas in Britain. We show that, on average, housing costs rise one-for-one with the net earnings of households. We rank places in terms of the costs of housing, for a given level of earnings, and consider to what extent these differences in housing costs are explained by various local amenities such as climate and pollution. Our research innovates on previous work by using micro data on housing transactions and panel data on individual earnings. These data allow us to control carefully for differences in structural attributes of housing, to control for sorting of different types of worker into different locations and to calculate post-tax earnings using income tax and National Insurance rates.

Our paper begins with a brief overview of related literature in Section 2, leading on to some theoretical discussion in Section 3. Section 4 discusses the data and empirical methods and is broken down into a number of subsections for ease of exposition. Section 5 provides the detailed results and Section 6 provides general conclusions.

2. Literature

The methods we use follow a long tradition of similar work on US cities, originating in Rosen (1979) and Roback (1982), and developed in Blomquist et al (1988), Gyourko and Tracy (1991), various papers by Glaeser and co-authors (Glaeser and Maré 2001, Glaeser, Kolko and Saiz 2001), Gabriel and Rosenthal (2004), and Albouy (2009) amongst others. To our knowledge similar methods have only been applied in Britain once (Srinivasan and Stewart 2004), using one year of data, limited information on housing characteristics, and an administrative spatial geography rather than one defined around labour market areas. The technique has been applied in other national contexts (e.g. Berger, Blomquist and Peters 2003). The basic idea in all these studies is that the amenity value or quality of life in a city, labour market or other location can be measured using the difference between housing costs in that location and expected earnings in jobs that are accessible from that location. Underlying this reasoning is the principle of spatial equilibrium, which assumes that a large enough group of people are sufficiently geographically mobile to ensure that, in the long run, spatial disparities in their economic welfare are eliminated. This theoretical reasoning is set out in more detail in the next section, but if spatial equilibrium holds this means that cost-earnings differentials compensate for area level amenities and dis-amenities.

A separate strand of literature in the UK provides descriptive evidence on the relationship between housing costs and earnings, often as a means to describe affordability of housing and inequalities in the cost of living (e.g. Wilcox 2009). This literature implicitly views high housing costs relative to earnings as an indication of an affordability problem, and as an issue of inequality. The most common indicator of affordability - the *ratio* of housing prices or housing costs to earnings - may, in any case, be a poor indicator of inequalities if we are worried about differences in standards of living. For example, a household facing a 20% housing cost to income ratio on an income of £20,000 is potentially far worse off than in a household facing, for the same housing quality, a 20% housing cost to income ratio on an income of £100,000. In the empirical work in this report we work mainly with cost-earning differences rather than cost/earnings ratios, although we also carry out an analysis based on log cost-earnings ratios that suggests that both approaches lead to similar (though not identical) judgements about the costs of different locations.

There remain, however, important theoretical tensions between these two perspectives which cannot be resolved by empirical analysis. In spatial equilibrium, cost-earnings differentials compensate for area-level amenity differences. The affordability perspective on the other hand ignores differences in amenities and considers only the monetary costs. From the spatial equilibrium perspective, households are free to choose where to live and work given the earnings, prices and amenities that characterise the potential choices. The affordability perspective assumes that households face constraints which prevent them moving elsewhere, and so they can remain substantively disadvantaged by where they live and work, relative the alternative options. Our maintained assumption in this paper is that places differ substantially in terms of the non-wage amenities they offer, that people do choose where to live with these amenities in mind, and that these amenities need to be taken into account when evaluating the advantages and disadvantages of different places.

3. Theoretical background

Underlying the idea that housing costs minus earnings differentials provide an indicator of area-level amenities is the theoretical principle of spatial equilibrium in the location decisions of workers and firms. This theoretical framework is set out in Roback (1982). In this model, identical working households will pay higher costs (primarily housing costs) and/or accept lower wages to live in places with abundant amenities and high quality of life. Wages and land costs must adjust to make households indifferent between locations. The equilibrium wage and land costs must also make profits for firms equal in all locations, so that firms have no incentive to move. If the amenities that benefit working households also benefit firms (e.g. if good weather reduces production costs), then firms will be willing to pay higher rents and higher wages in high-amenity locations. Therefore, high-amenity places have high commercial rents and housing costs, but the effect on wages is ambiguous. If the amenities that benefit workers impose a cost on firms (e.g. clean air) then firms must pay lower wages and lower rents to locate in high-amenity places. In this case, high-amenity places have lower wages, but the effect of amenities on rents (and land values) is ambiguous.

As a consequence of these two equilibrium conditions - spatial equilibrium in firm location and in household location – housing costs may rise or fall with the wages paid in different labour markets. In other words, if we were to plot labour market housing costs against household labour market earnings net of taxes, the line could be upward or downward sloping. The line will tend to be upward sloping to the extent that different places offer big advantages and disadvantages to firms but differences between areas are less important to workers. The line will tend to be downward sloping to the extent places offer big advantages and disadvantages to workers but differences between areas have less impact on firms.

Note however, that if we have a set of spatial labour markets that are completely substitutable as far as workers are concerned (except for differences in costs and wages), then any difference in the skill-adjusted earnings that a household can expect in different labour markets must be offset by a rise in housing costs for quality-adjusted housing. By 'skill-adjusted' earnings, we mean the earnings that a given type of worker, with a specific set of skills, experience etc. can expect in different labour markets. By 'quality adjusted' housing, we mean housing that is the same type and size and has similar structural attributes, where 'structural' attributes are taken to mean those attributes that could remain the same if the house was moved to a different location (as distinct from attributes that depend on where it is located). The implication is therefore that, for equivalent areas, quality-adjusted housing costs should rise £-for-£ with expected skill-adjusted household earnings to ensure that income after housing costs is equal across areas for identical households consuming the same type of housing in different locations. Intuitively, this must be true for the set of potentially mobile households who determine wages and housing prices, otherwise these households would have an incentive to change location.

Suppose we can observe similar working households in similar housing units in different places, and that these households perceive these places as equivalent on dimensions other than wages and costs. It can be seen from the above discussion above that a plot of the quality-adjusted households' housing costs against their skill-adjusted net earnings would follow a 45 degree upward sloping line. It follows further, that if we plot housing costs against net earnings for a set of places which offer *different* amenities to households, places represented by points above this 45 degree line are relatively expensive places to live given the potential earnings. These higher costs must be compensated by non-wage benefits from amenities so places above the 45 degree line are high amenity or high quality of life places. Places below the 45 degree line are relatively cheap places to live given the potential earnings, so the lower relative housing costs must be compensating for some disamenity. Another way to look at this is to see 'real' earnings as earnings net of housing costs. Places with high real earnings are below the 45 degree line and these high real earnings are compensating for these being otherwise undesirable places to live. Places above the 45 degree have low real earnings because they are desirable places to live.

Writing place-specific quality-adjusted housing costs (or rents) as r_j, area specific skill-adjusted household earnings as w_j and the amenity value or quality of life in place j as q_j, the relationship between housing costs, wages and quality of life is:

$$\Delta r_j = \Delta w_j + \Delta q_j \text{ or } \Delta q_j = \Delta\left(r_j - w_j\right) \qquad (1)$$

where the Δ means a difference from some baseline reference place (e.g. the place with the average cost-earnings differential). Therefore, with data on place-specific, quality adjusted housing costs and skill-adjusted earnings, a place-specific quality of life estimate (in monetary terms) can be obtained by looking at the cost-earnings differential relative to the average in the sample. More can be learnt about the role of various amenities in generating these 'quality of life' differences between places by taking the estimates of quality of life obtained above and applying regression analysis to look at the factors associated with this quality of life. For example, with a set of data on amenities such as pollution, climate, accessibility, congestion etc. we can regress the quality of life estimates on these amenities and interpret the estimated coefficients as showing the average contribution of each amenity to quality of life differentials.

So far in the discussion we have assumed that households do not change their consumption of housing services (e.g. size of house) in response to changing housing costs. However, economic consumer theory predicts that households substitute towards smaller housing units as housing prices rise, to maintain an optimal mix between the consumption of housing services and other goods (unless preferences are characterised by a zero elasticity of substitution between housing and other goods). Without formally specifying a functional form for preferences and the marginal rates of substitution between consumption and housing, it is not possible to predict exactly how households will behave when faced with differences in the price index of quality-adjusted housing. One common assumption that is made in the literature is that households have Cobb-Douglas preferences, which implies that the share of housing expenditure in total expenditure remains constant. This assumption gives rise to an alternative specification of the spatial equilibrium relationship between housing prices and earnings, which can be expressed in terms of a log house price index (a_j) and earnings index (w_j), where housing expenditure on housing h is $r_j = a_j h$[1]:

$$\Delta \ln a_j = \frac{1}{share} \times \Delta \ln w_j \qquad \text{or} \quad \Delta \ln q_j = \Delta \ln a_j - \frac{1}{share} \Delta \ln w_j \qquad (2)$$

In this formulation, the equilibrium for places with equivalent amenities is an upward sloping 45° line when the log house price index is plotted against the log of net earnings, weighted by the 1/share of housing expenditure in total expenditure. Deviations from this line provide an alternative estimate of the area-specific quality of life indices. Note the two methods implied by equation (1) and (2) will be equivalent for small (marginal) changes around a fixed quantity of housing consumed (h_0) per household, because:

[1] see Albouy 2009 for a full exposition

$$\frac{\partial \ln a_j}{\partial \ln w_j} = \frac{1}{share}$$

$$\Rightarrow \frac{\partial a_j}{\partial w_j} \cdot \frac{w_j}{a_j} = \frac{w_j}{a_j h_0}$$

$$\Rightarrow \frac{\partial a_j h_0}{\partial w_j} = 1$$

$$\Rightarrow \frac{\partial r_j}{\partial w_j} = 1$$

In the empirical work below we favour the simple linear relationship in (1) which avoids the assumption that housing is a fixed share of total expenditure. Given that the relationships are equivalent for marginal price differences and that the equilibrium relationship in (2) is derived assuming marginal changes, we do not think this simplification should be too controversial. However, we will report results based on the alternative constant-share assumption too and compare the results derived from these two theoretical formulations.

There are several other theoretical considerations which may cast doubt on the general validity of either of these simple equilibrium models. Firstly, the basic theory outlined above assumes that people have identical preferences over amenities. This is obviously not likely to be true in reality, and heterogeneity in preferences makes the picture more complicated. People with a strong preference for a specific type of amenity (e.g. the sea) will be willing to pay more than other people to live in places that offer that amenity (e.g. coastal labour markets). This induces sorting of people with different preferences in to different places. In this case, the cost-wage differential between coastal and non-coastal places represents the valuation of 'marginal' residents who are indifferent between living in a coastal and non-coastal location given wage-cost differentials. This valuation is somewhere between the valuation of those with strongest and those with the weakest preferences for coastal locations, but where exactly it lies in this range is difficult to determine without imposing more theoretical structure on the problem (e.g. Bayer, Ferriara and McMillan 2007). Preferences in this context could also include inherited traits that are related to specific locations - e.g. a preference to live in a particular place if you are born there.

Heterogeneous preferences also make welfare comparisons rather difficult, even under the assumption of spatial equilibrium. One thing for sure is that most people are at least as well off (in utility terms) staying where they are as they would be moving anywhere else. There is also a group of 'marginal' residents in each location who are exactly as well off living where they are as they would be in their next best location. There are other groups of 'infra-marginal' residents who are strictly better off where they are than elsewhere and would accept much lower wages or higher housing costs before they were induced to move out. But beyond this it is very difficult to make meaningful comparisons of the wellbeing of different people with different preferences in these different locations.

Constraints on the supply of housing in different locations can also matter if people differ in their preferences, and if places offer idiosyncratic benefits. If people all have the same preferences, then constraints on the supply of housing in one location that offers a particular amenity (e.g. coast line) do not raise prices in that particular location, but in all locations offering that amenity (e.g. all coastal locations). This is because demand for any one area is completely elastic, given the spatial equilibrium assumption, and therefore the price of an amenity cannot be different in one location than another. But when people have different preferences over locations, even when they offer the same amenities, things can look very different. Supply constraints in one location can make an amenity there look more expensive, because those with the strongest preferences for that location want to live in that location, and are prepared to pay more for any amenity in that location than other people. Again, as in the case of heterogenous preferences described above, the implication is that the price differentials between areas measure the value of these areas to the marginal household, which is not necessarily the average household in terms of preferences.

A further consideration is the degree to which people are mobile. The simple spatial equilibrium model assumes that people are at least potentially mobile, and if they don't move it is because the expected benefits of doing so in terms of net earnings gains and amenity changes do not outweigh the costs (including any short run moving and transactions costs). Very high moving and transactions costs, a high degree of residential inertia, poor information about the earnings, costs and amenities on offer in different locations, and other sorts of frictions will cause distortions that mean that cost-earnings differentials do not accurately reflect willingness to pay for amenities in different labour markets - at least in the short run. In the empirical analysis below we consider averages over a 10 year period to mitigate any problems due to short run adjustment costs. It is also worth noting that our data on employees indicates that around 3.5-4% of workers each year move workplace between the Labour Market Areas considered in our analysis, implying about 680000 inter-labour market household migrations every year (using a figure of 1.7 workers per household, which we discuss in our empirical work below). Data from the Land Registry also shows that there are 1.2 million housing sales each year - about 9-10% of the stock of owner-occupied housing, although we have no data on what proportion of these are associated with inter-labour market migration. On balance, these figures suggest that house moves and inter-labour market migration is not uncommon.

These caveats notwithstanding, we take reasonably seriously the idea that cost-earnings differentials are informative about the willingness to pay for the amenities offered by different labour markets. Even taking the extreme position that people are completely immobile, the relationship between wages and housing costs is still a very interesting one. If quality-adjusted housing costs rise or fall with wages (or GDP, GVA per worker etc.), then nominal wage disparities between labour markets or other spatial areas are not very informative about the disparities in consumption expenditure for workers in these different labour markets and so uninformative about disparities in material standards of living.

The key challenge then in the empirical work is in implementing Equation (1), given the ambiguities about how to define housing costs and earnings, how to adjust housing costs for spatial differences in housing quality and how to adjust wages for the sorting of workers of different skills into different labour markets. In the next section we describe our approaches to these problems.

4. Data and empirical implementation

Equation (1) requires measurement of households' labour-market specific, skill-adjusted expected earnings and quality-adjusted expected costs of housing. The main substance of this paper is in estimating these earnings and costs. We have very good micro data on employee earnings and housing market transactions which, we argue, allows us to go much further than previous work in carefully defining these earnings and cost variables. However, deriving what we need from data on individual employee earnings and housing sales prices is not trivial and inevitably requires a lot of auxiliary assumptions and statistical adjustments. The main challenges are: a) defining labour market areas; b) adjusting earnings measures for taxes and differences in skill; c) adjusting housing prices for differences in structural quality; d) translating house prices into annual costs, taking into account if and how households incorporate capital gains into evaluation of costs and benefits over the lifecycle; and e) treatment of housing taxes, maintenance, insurance, transactions other area-specific costs and household size. In this section we describe the methods and data we employ to address these challenges.

4.1. Labour market definitions

Our starting point for defining labour market areas are the UK Travel to Work Areas (2007 definition based on 2001 Census data) developed by Newcastle University for the Office for National Statistics. These TTWAs are 243 contiguous zones derived on a principle of self-containment that requires that 75% of the workers in a zone live in that zone and that 75% of the residents in a zone work in that zone. TTWAs are thus functional commute-based labour market zones, many of which are distinct cities and their surroundings. Our analysis divides the UK into 157 TTWA-based “labour market areas” (LMAs) of which 79 are single “primary urban” TTWA and 78 are “rural areas”. We reached this classification in three steps. First, we identified the primary urban TTWAs as those centred around, or intersecting urban-footprints with populations of 100,000 plus (e.g. London, Plymouth). Second, we identified stand-alone "rural" TTWAs as those with an average sample size in our individual-level earnings data greater than 200 annually (e.g. Inverness, Scarborough). Third, we grouped remaining TTWA (with sample sizes below 200) into contiguous rural units, given the spatial distribution of TTWA defined in (a) and (b) (e.g. North Scotland, South West Wales). The geographical LMA boundaries are shown in Appendix B. Gibbons, Overman and Pelkonen (2010) provide a wide range of statistics for wage differences across these areas. We use the National Statistics Postcode Directory (NSPD) to allocate workers and properties to TTWAs, and hence to LMAs.[2]

4.2. Skill-adjusted earnings

Earnings data comes from the Annual Survey of Hours and Earnings (ASHE) and its predecessor the New Earnings Survey (NES), from 1998-2007. ASHE/NES is constructed by the Office of National Statistics (ONS) based on a survey of a 1% sample of employees on the Inland Revenue PAYE register for February and April. The responses to the survey are provided by employers, rather than the employees themselves. The sample is of employees whose National Insurance numbers end with two specific digits (these have been the same since 1975), meaning ASHE/NES provides an individual level panel, in which workers are observed for multiple years. The sample is replenished as workers leave the PAYE system (e.g. to self employment, retirement, overseas or death) and new workers enter it (e.g. from school, self-employment, immigration).

[2] The NSPD provides a lookup from every UK postcode to higher-level geographic units (e.g. output area, government office region, country, etc).

NES/ASHE records information on occupation codes, using Standard Occupational Classification (SOC), industry code, whether the job is private or public sector, the workers age and gender and detailed information on earnings including base pay, overtime pay, basic and overtime hours worked. The SOC codes change from the 1990 to the 2000 definition after 2002. We use information on gross annual earnings for the previous tax year as our measure of annual earnings. Gross earnings includes basic pay, plus overtime, bonuses and shift payments. From this gross pay, we estimate individual annual pay net of taxes and National Insurance contributions using the annual thresholds and marginal rates available from Inland Revenue data (at http://www.hmrc.gov.uk/stats/).

ASHE provides information on home and work postcodes, While the NES provides similar individual data it only reports work, not home, postcodes. For our main analysis, we assign workers to LMAs based on their work postcode in each year, allowing us to use data from the whole time period. Given the self-containment principle on which TTWAs are constructed, the work TTWA will also be the home TTWA for the majority of workers. This means that work based area mean wages will correspond quite closely to home based area mean wages, although there are differences and we have also carried out the analysis using home postcodes, for those years for which they are available.

Using individual workers' net-of tax annual earnings assigned to workplace LMAs, we estimate skill-adjusted LMA-specific mean net earnings by recovering the area fixed effects estimates from a regression of log net earnings on individual characteristics and LMA fixed effects. In these regressions, we firstly adjust for observable skill categories by controlling for worker age, gender and occupation. In this first specification we group workers into classes according to 3-digit SOC, gender and 5-year age groups and use these classes as fixed effects[3]. Secondly, to adjust more completely for time invariant unobserved worker characteristics we control instead for individual

[3] Note, the SOC classification changes in 2003 to SOC90 to SOC2000 which we accommodate by defining a different sets of occupational classes for 1998-2002 and 2003-2007

worker fixed effects. In these individual worker fixed effect specifications we estimate LMA wage differentials from workers that move between LMAs over the period they are observed in the ASHE/NES sample. In both case, estimation is done using the two way fixed effects algorithm developed by Abowd, Creecy and Kramarz (2002) as implemented by Ouazad (2008), with LMAs as one set of fixed effects and worker classes or individual identifiers as the second set of fixed effects. We then recover and re-normalise the LMA fixed effects estimates such that they estimate the LMA specific earnings of workers with characteristics corresponding to the national mean.

To summarise, we predict area specific annual earnings using:

$$\ln netpay_i = b_j + f_i + v_{it}$$

where b_j is an LMA fixed effect and f_i is either a pseudo individual effect, based on grouping on individual observed characteristics (3 digit SOC, age gender) or an individual fixed effect based on the panel employee identifier. We then predict the area-specific net earnings differentials for a person with national mean characteristics f_0, after appropriately re-basing so that the predictions yield absolute levels of log wages, rather than percentage differentials, as:

$$w_{0j} = \exp\left(\hat{f}_0 + \hat{b}_j\right)$$

These LMA earnings estimates are standardised to 2007 price levels using the Consumer Price Index (CPI).

4.3. Quality adjusted housing prices

Housing transactions data comes from the Nationwide Building Society, and our sample records transactions for which the Nationwide provided mortgages between 1998 and 2007. The sample contains around 876000 property transactions, with between 60,000 and 128,000 sales in each year. The average number of annual sales in an LMA is 550, with a minimum of 25 and maximum of 22500. The data records the price plus a large number of property characteristics.

A regression-based approach is used to adjust housing prices for differences in structural housing quality, in a similar way to that described for earnings above. However, rather than estimate LMA fixed effects we estimate separate LMA-by-year log-price regressions[4] with controls for floor area, age and indicators for number of bathrooms, number of bedrooms, tenancy type (freehold, leasehold, feuhold), type parking (none, space, garage), structural type (detached, semi-detached, terraced, flat, bungalow, purpose built flat/maisonette, converted flat/maisonette), central heating, new build and quarter of sale. We also include controls for distance to the LMA centroid and interactions of this distance with GB National Grid Reference easting and northings. From these regressions, we recover LMA-by-year estimates of the price of a property with national mean characteristics, at the average distance and direction from the LMA centroid.

To summarise, we estimate

$$\ln price_{ijt} = x'_{it}\beta_{jt} + a_{jt} + \varepsilon_{ijt}$$

Where $price_{it}$ is the sales price of property i in year t, x_{it} is a vector of property characteristics and a_{jt} is an LMA-by-year constant term and ε_{it} is an error term. From this equation we predict an area-specific sales price index, based on a property with national mean characteristics x_0:

$$\tilde{a}_{0jt} = \exp\left(x'_0\hat{\beta}_{jt} + \hat{a}_{jt}\right)$$

This index is then normalised to 2007 prices using the Consumer Price Index.

[4] Note, in the wage regressions we will focus on estimates with individual fixed effects so it is infeasible to obtain LMA-by-year skill adjusted wage estimates. In the house price regressions it is obviously not possible to estimate fixed LMA price indices from models with house fixed effects (because houses do not move), so we estimate LMA-by-year quality-adjusted price indices.

4.4. Imputing annual mortgage related costs

Moving from a quality-adjusted house price index to estimates of annual costs is not straightforward and is the most assumption-heavy step in this type of analysis. We adopt a number of approaches. The simplest is to use interest-only costs giving an annual cost estimate:

$$\tilde{r}_{0jt} = lv_t \times \tilde{a}_{0jt} \times i_t + (1 - lv_t)\,\tilde{a}_{0jt} \times s_t$$

Where lv_t is the year t national average loan to value ratio, i_t is the year t standard variable rate of interest on mortgages (from Bank of England data[5]), s_t is the year t interest rate on savings accounts ('notice accounts', from Bank of England data), and $\tilde{a}_{0jt}$ is defined above.

Secondly we implement a 'myopic' measure of mortgage costs, which includes the mortgage interest, the full cost of repaying the loan over 25 years, and the cost of the down-payment (note: this is roughly equivalent to the 25 year cost of a 100% mortgage on the full house price assuming $i_t \approx s_t$). This method assumes that the purchaser ignores the value of their asset at the end of the 25 year term and gives an annual cost estimate:

$$\tilde{r}_{0jt} = \left\{ lv_t \times \tilde{a}_{0jt} \times i_t \times \frac{(1+i_t)^T}{(1+i_t)^T - 1} + (1 - lv_t) \times \tilde{a}_{0jt} \times s_t \frac{(1+s_t)^T}{(1+s_t)^T - 1} \right\}$$

Lastly we calculate a user-cost based measure that takes into account capital appreciation:

$$\tilde{r}_{0jt} = lv_t \times \tilde{a}_{0jt} \times \hat{i}_t + (1 - lv_t)\,\tilde{a}_{0jt} \times \hat{s}_t - \tilde{a}_{0jt} g_j$$

in which $\hat{i}_t$ and $\hat{s}_t$ are real interest rates (deflated by the CPI) and g_j is a parameter specifying expected annual house price growth. We define this in two ways, either fixing expected capital gain at $g_j = g = 0.021$ (the real growth rate of GDP 1975-2009) or using LMA-specific expected long run growth rates based on $g_j = g \times g_{j,98-07} / \bar{g}_{98-07}$ where $g_{j,98-07}$ is the LMA-specific observed price

[5] See http://www.bankofengland.co.uk/statistics/index.htm (accessed December 2010)

growth rate between 1998 and 2007 in our data and $\overline{g}_{98-07}$ is the mean growth rate of our estimated house price index ($\tilde{a}_{0jt}$).

4.5. Adding in local taxes, maintenance and transactions costs and defining household size

There are a variety of other costs that vary by LMA, that should be taken in to account in our LMA cost measures. Local taxes (Council Taxes) are raised by Local Authorities on property according to value (based on the value in 1991) and in some specifications we add in the mean area Council Tax ($ctax_{jt}$) to the mortgage costs for the mean property (as described in 4.4)[6]. We also allow for maintenance and transactions costs as a fraction (δ) of mortgage costs, setting δ=0.19 based on the ratio of maintenance, transaction and insurance costs to mortgage costs reported for home-owners with a mortgage in the 2001/2-2007/8 Expenditure and Food Surveys (EFS).

The Expenditure and Food Survey transactions costs do not include Stamp Duty, which is the UK tax on property purchases. We therefore impute Stamp Duty using the predicted LMA house price index and data on the Stamp Duty thresholds and rates in each year. These have varied over the years, but in 2007 were 0% up to £12500, 1% for sales £125000-£250000, 3% for sales £250000-£500000 and 4% above that. Note, the relevant % tax is payable on the full purchase price, not the amount above the last threshold. We then need to estimate the annual cost of the Stamp Duty on housing transactions, which requires some assumptions about the expected duration of tenure in each owner occupied home. No UK data source records the length of completed housing tenure spells. To estimate average tenure length, we divide the total stock of owner occupied housing in England and

[6] Note, we aggregate up LA mean council tax to LMAs using weights based on the proportion of LMA population in each LA. The assignment of mean council taxes to the LMA specific price index is an approximation, given that the price index corresponds to the price of the national mean house type in an LMA, not the price of the average house in the LMA. It is difficult to improve on this approximation given that council tax is set in discrete bands based on house value in 1991, and we have no way of recovering the actual council tax band for each property in our dataset.

Wales from the GB Census (2001), divided by the average number of housing sales per year (taken from Land Registry data www.landreg.gov.uk), which gives us an expected length of tenure in owner occupied housing of approximately 10 years. An annual estimated Stamp Duty payment ($stamp_{jt}$) is then obtained by dividing the total Stamp Duty payable by 10.

To arrive at a per worker figure for housing costs, we divide the total annual mortgage costs maintenance, insurance and transactions costs, plus council tax and Stamp Duty, by the average number of workers (*h*) in home-owning households with a mortgage. Again, 2001-7 Expenditure and Food Surveys are used to provide the average national figure of 1.7 workers per household. Our final annual LMA-by-year housing cost estimate is thus:

$$r_{0jt} = \frac{\tilde{r}_{0jt}\left(1+\delta\right)+ctax_{jt}+stamp_{jt}}{h_{jt}}$$

This LMA-by-year cost estimate is finally de-annualised to remove time trends, and averaged to give a single cross section estimate of r_{0j}.

4.6. Other potential issues

So far the discussion has taken no account of differences in the price of goods and locally traded services which will also affect the cost of living in different locations. Clearly some adjustment might be made for these prices too, if there is substantial variation across locations, because it is the purchasing power of income after deducting housing costs that should be equalised across locations that workers perceive as substitutes. Lack of data on local prices in the UK makes this adjustment difficult in practice, and so we follow previous practice and consider only housing costs, assuming that other prices are constant across areas.

We have also ignored non-labour income such as benefits, retirement income and income from assets. Non-labour income will matter to the extent that it is a significant proportion of personal income, and the value of this income varies across labour markets. Non-labour income could be an important consideration for low pay workers because of income support and assisted housing costs.

Implicitly, in the this study we are considering the trade off that *earners* face between higher wages and housing costs, and hence the cost-earnings differential should be thought of as a measure of the amenity value of different labour markets to those working in the labour marker. For earners, we do not expect non-labour income to have a big effect on our results, because it is a small share of income for those in the labour market. For example, the Family Resources Survey for 2006-7 shows that for households with earnings above the bottom quartile, non-labour income accounts for only around 10% of total household income (authors' own estimation from FRS data). In the empirical results presented below we assume that this non-labour income is not a major factor governing people's choices of where to live and work.

4.7. Amenity data

For the final step in our analysis, we require data on local amenities at the LMA level. Amenity data comes from a number of sources. A count of households in each area is derived from the number of addresses recorded for active postcodes in the 2008 National Statistics Postcode Directory. Surface area of the labour market units is obtained from GIS boundary data on travel to work areas. A measure of employment accessibility was obtained using a ward-to-ward road generalised transport cost matrix (GTC) provided by the Department for Transport, combined with the ONS Business Structure Database (the BSD). The BSD records employment at the majority of business addresses. For each ward we sum up the employment in other wards, using inverse-cost weights, where the costs are those in the GTC matrix. From Landsat satellite data on land cover (Landcover map 2000) we obtain the proportion of each LMA in various uses: urban (including continuous urban and suburban land cover), woodland (deciduous and coniferous), grassland and water. From Ordnance Survey GIS data we obtain lengths of coastline, area of National Park, length of rivers, length of primary roads, number of rail stations and number of motorway junctions within each LMA. The Ordnance Survey Panorama Digital Elevation data allows us to construct various measures of elevation, slope and ruggedness.

Air quality data on NOx (nitrogen monoxide/dioxide), NO2 (nitrogen dioxide), PM10 and PM2.5 (particular matter < 10 and 2.5 μm in diameter) has been obtained from the UK Air Quality Archive (www.airquality.co.uk) and aggregated to LMA level. We also have climate data from the UK Met Office including rainfall intensity (precipitation on days when there is any rain >1mm averaged from 1961-1990), temperature related data (number of days when temperature is below 15.5°C and heating is required, and number of days above 22°C when cooling is required) and sunshine hours.[7]

Crime rate data comes from the Home Office (for England and Wales only) at Local Authority level. In addition we collected data on the number of museums and art galleries per capita by a search of web-based resources. Data on road congestion (mean speeds during busy periods) was provided on a basic GIS road network by the Department for Transport.

4.8. Using these data to give cost-earnings relationships and 'quality of life' estimates

To summarise: our empirical analysis is based around the ideas of spatial equilibrium and the trade off between earnings and housing costs (the theoretical details are set out in the existing literature cited above). In line with other work of this type we set aside the more subtle concerns about heterogeneity of preferences, local goods prices and imperfect mobility that we have just discussed. Clearly, these complications are important, but relative to alternative approaches (e.g. surveys or contingent valuation, which suffer from their own problems) our approach allows us to provide an indication of the value of *overall* quality of life differences across areas that have simply been unavailable hitherto.

We proceed as follows. First we construct expected skill-adjusted net-of-tax earnings for workers in different spatial labour markets using micro data on individual worker's pay and information on their characteristics and place of work (described in 4.2). We then use data on

[7] http://www.metoffice.com/climatechange/science/monitoring/ukcp09/index.html (accessed Dec 2010)

property transactions to estimate quality-adjusted housing prices in these labour markets and use these prices to estimate annual housing costs, with optional adjustments for maintenance and local taxes (described in 4.3-4.5). Plotting these estimates of expected housing costs against expected net wages provides descriptive evidence of the trade off that workers face in deciding where to live and work. As discussed in Section 3, the locus that describes the relationship between marginal differences in housing costs (for identical housing units) and marginal differences in earnings across LMAs offering identical amenities is an upward sloping 45° line when housing costs are plotted against expected net earnings (Equation 1). In these plots, we also estimate the (non-linear) equilibrium relationship between costs and earnings using a locally weighted least squares (lowess, as implemented in STATA) smoother.

We next use the cost-earnings differential to estimate the value to households of each LMA, as in Equation (1). These cost-earnings differentials can be used to rank labour markets according to their 'quality of life' - which is some average valuation of the amenities that each labour market offers. The LMA-specific quality of life indices are therefore:

$$\Delta q_{0j} = \Delta r_{0j} - \Delta w_{0j}$$

Finally, we regress these cost-wage differentials on variables representing amenities such as congestion, population and employment accessibility, climate, pollution, transport and terrain.

$$q_j = \mathbf{z}_j' \boldsymbol{\lambda} + u_j$$

where w is a vector of area-specific amenity variables described in 4.7.

Our analysis is carried out at the LMA level as defined in 4.1.

4.9. Alternative methodology assuming fixed shares of housing

The methods described above are based on marginal changes in earnings and prices as workers move from LMA to LMA, assuming households do not substitute towards smaller housing units as the house price index increases. Our underlying assumption here is that there are households of similar types occupying houses with national mean housing characteristics in each of our LMAs, so the earnings and cost differentials reflect the valuation of the LMAs to these households. However, as discussed in section 3, in economic consumer theory predicts that optimising households will change their mix of consumption goods and housing when they move to higher-land price areas, so the same household type would not, in theory, be found in the same housing type in differently priced LMAs. For example, the average household moving from Newcastle to London may prefer to reduce the size of their dwelling as well as reduce consumption of other goods and services.

Therefore as an alternative, we use the equilibrium locus between the housing price index and earnings index described by Equation (2)

$$\Delta \ln q_{0j} = \Delta \ln a_{0j} - \frac{1}{share} \Delta \ln w_{0j}$$

For this exercise, we need a value for the share of housing expenditure in total expenditure. We derive this from the 2001-7 Expenditure and Food Surveys (EFS), which gives us a figure for *share* = 0.31 i.e. expenditure on housing in Britain accounts for 31% of total expenditure over this period. As a robustness check, we compare the quality of life indices based on this method with the indices based on imputed housing costs.

5. Results and Discussion

5.1. Cost-earnings relationships

To begin with we present a simple plot of median estimated per-worker housing costs against median estimated individual net earnings at the area level (Figure 1, top panel). Each label is a labour market area. The red labels are those LMAs we classify as urban, the green ones are LMAs we classify as rural. The dotted line is the fitted (lowess) line through these points, and the solid line is the 45 degree line. The axis units are in £1000s. The linear regression coefficient estimate and heteroscedasticity-robust standard error is also reported. Housing costs are calculated using the interest-only method described in section 4.4. We have not, in this picture, adjusted earnings for different skill levels or other characteristics, nor have we adjusted housing for the type and quality of physical structure.

In the top panel of Figure 1, individual expenditure on housing rises with earnings, by about 40p per £1 of earnings as we move from low-wage areas on the left to high wage areas on the right. However, some of the lowest wage, primarily rural areas on the left lie well above the 45 degree line implying that they are relatively high-cost/high amenity areas. Conversely, the high-wage urban areas on the right - including London - lie below the 45 degree line implying that they are relatively low cost/low amenity labour markets. However, we should not read too much into these figures at this stage because we have not adjusted for structural housing quality or skills. Firstly, we do not know if higher cost labour markets simply have bigger houses. Secondly we do not know if high-earnings labour markets offer high wages to equivalent workers or have a high average wage because of sorting of high skill workers.

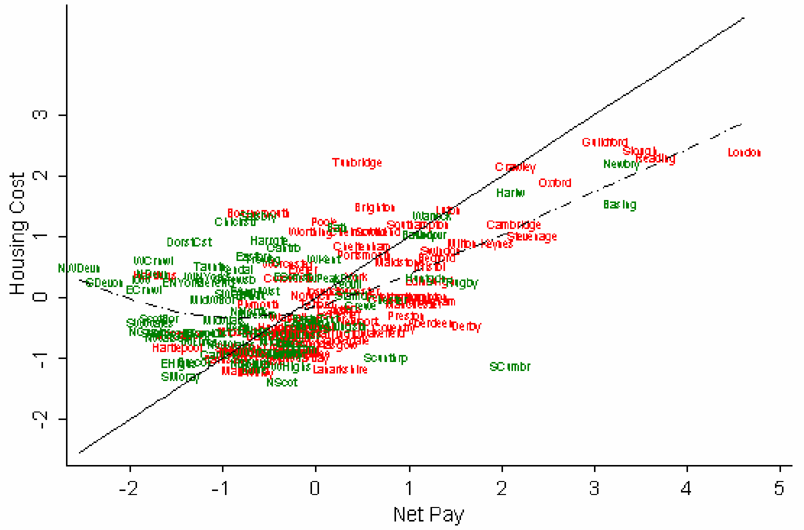
In the second panel of Figure 1, we adjust housing costs for housing quality, and adjust earnings for skill differences using observable indicators of worker skills (occupation, age, gender) as set out in Section 4, i.e. Figure 1 plots Δr_{0j} against Δw_{0j}. After adjusting for skills and housing quality, it is evident that housing costs rise roughly one-for-one with labour market earnings as one moves from low-wage to high-wage areas. The OLS regression coefficient is 0.954 (s.e. 0.127). Both high-wage and low-wage LMAs tend to lie above the 45 degree line, and there is some curvature in the non-linear regression line, suggesting that both these types of area offer workers relatively high levels of amenities.

The third panel of Figure 1 further adjusts earnings differences for sorting on unobservable individual characteristics using individual fixed effects (i.e. the LMA earnings differentials are estimated from workers who move between LMAs). The linear regression coefficient falls slightly to 0.825, although this coefficient is not significantly different from 1. However, the relationship between housing costs and earnings is markedly non-linear, tending to fall slightly in the lower half of the earnings distribution as we move from low-wage to medium-wage areas. The relationship then rises steeply as we move from medium-wage to high-wage areas. By comparison with the 45 degree line, it is evident that both the low-wage (predominantly rural) and high wage (predominantly urban) LMAs have relatively high housing costs, and, implicitly (assuming spatial equilibrium), high amenities. The tendency for costs to fall with wages in the lower part of the distribution could indicate that in these predominantly rural areas, the general pattern is driven mainly by amenity differences that are important to residents, but which offer no productivity advantages. For example, high land costs in an area like W Cornwall (far left of the picture) tend to be associated with low wages relative to the average place in the middle of the picture. The implication is that the amenities here (e.g. sun, sand, sea and surf) may be enjoyed by workers, but are not conducive to high productivity, and so high land costs are offset for firms by low wages. On the other hand, where housing costs rise rapidly with wages on the right of the picture, the implication is that the general patterns are driven largely by amenities that are valuable for consumption and production, benefiting both residents and firms. For example, in moving from the centre of the picture to London, there is an apparent increase in both land costs and the wages that firms are prepared to pay. Figure 2 presents the figures using some alternative quality-adjusted housing cost estimates. The first panel adds in local Council Taxes, maintenance costs, and Stamp Duty (as detailed in section 4.5) which increases the general slope but does not change the overall picture. The second panel includes these costs and also adds in the annualised cost of the repayment of the capital and deposit (down payment) on the house purchase, assuming a 25 year term. Under this rather extreme assumption of workers evaluation of housing costs, the point OLS estimate suggests that costs increase even more rapidly with earnings (as we would expect), although again the coefficient is not statistically different from 1.

Figure 1: Association between housing interest payments and net earnings (£000s)

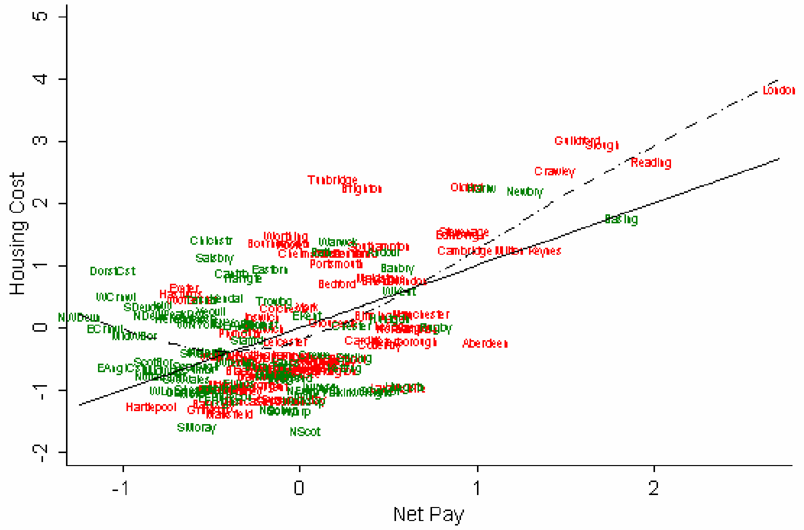
Median (no housing or worker control variables). 1.7 worker households

Coefficient 0.408 (0.055)



National mean housing and worker characteristics:

Coefficient 0.954 (0.127)



Individual pay fixed effects (movers)

Coefficient 0.825 (0.176)

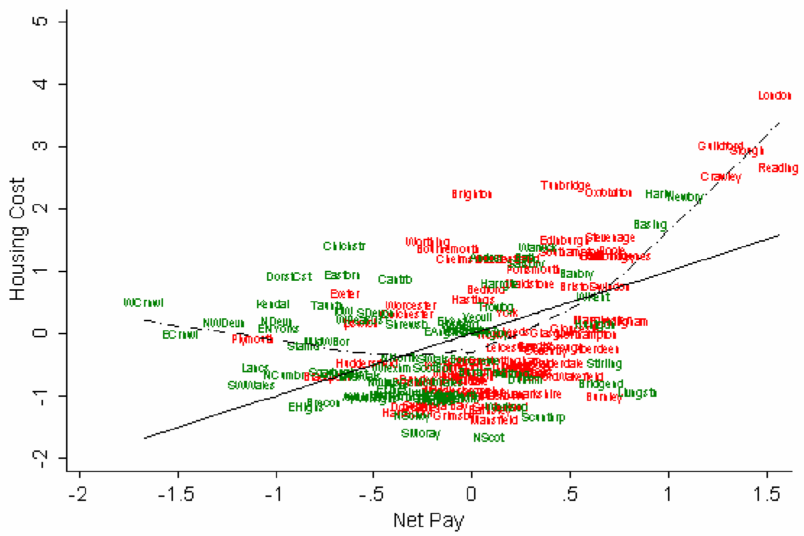
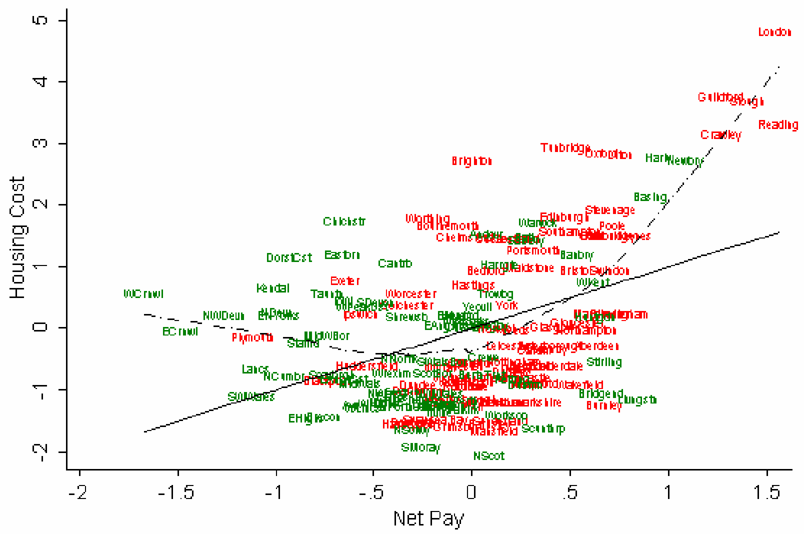


Figure 2: Association between housing costs and net earnings: alternative cost and earnings assumptions

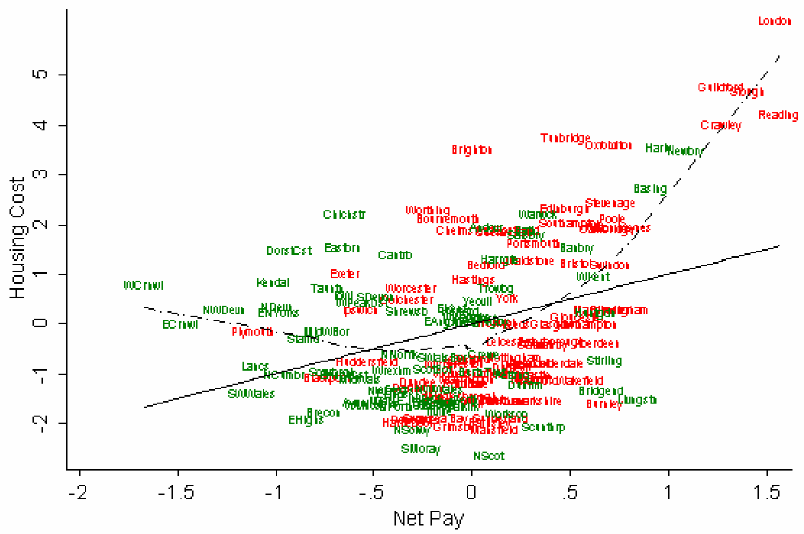
Adding in maintenance costs (11%) local council tax and stamp duty

Coefficient 1.028 (0.220)



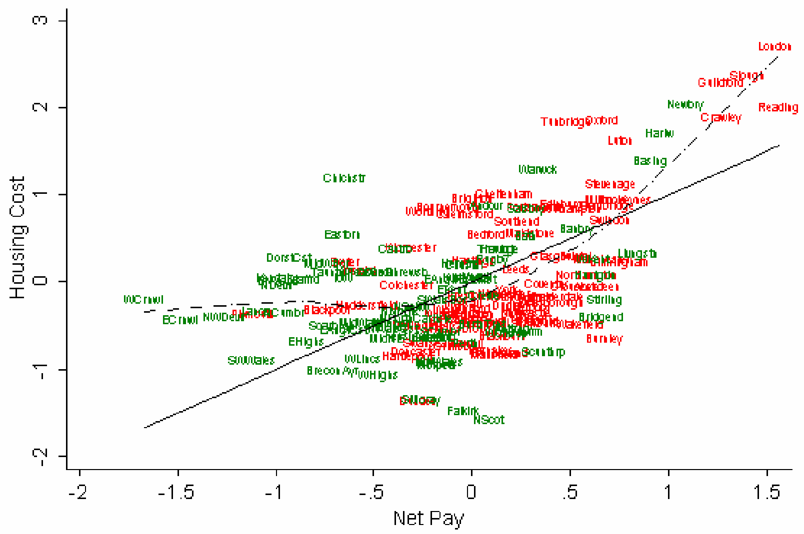
Myopic housing costs (full cost of mortgage and deposit) plus maintenance and council tax

Coefficient: 1.305 (0.281)



User costs and benefits, assuming area-specific price growth, maintenance, council tax and stamp duty (details in text)

Coefficient 0.736 (0.116)



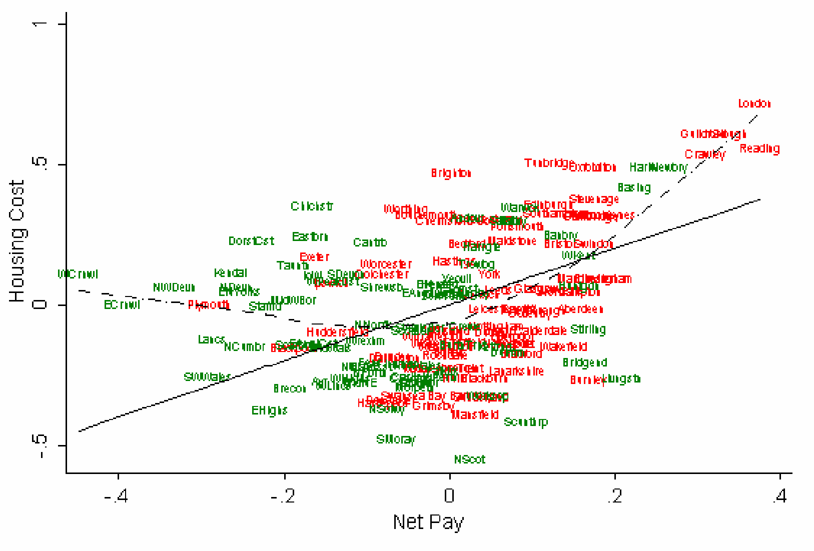
In the third panel of Figure 2 we move to user-cost based measures of costs and earnings, that allow for LMA specific capital growth in house price. This switch to user-costs reduces the variance of housing costs across LMAs because high price areas also tend to be high growth areas, and price growth reduces the user cost of housing. In fact, house price growth can outstrip the rate of interest making high-wage locations appear almost costless in user-cost calculations. Because of this, the maintenance cost, Council Tax, and Stamp Duty adjustments become quite important drivers of housing cost differences between LMAs. Stamp Duty in particular turns out to be a major contributor to the upward relationship between LMA differences in the user costs of housing and earnings.

There are some reasons to doubt that a user-cost approach is the right one for our purposes. Firstly, user cost calculations implicitly assume that workers realise the full capital gains when they sell their property, and draw this forward for consumption in earlier stages in the lifecycle. For most home-owners, this is never likely to happen, given the ongoing need for somewhere to live and imperfect capital markets. Secondly, these calculations also assume that workers can make judgements about long run expected real house price appreciation. Given that we could find almost no literature that provides estimates, nor real estate professionals who could confidently suggest a figure, we think it unlikely that home-owners are good at evaluating future house price gains. Lastly, we are not particularly convinced that expectation of house price gains are the main driving force behind worker location decisions. However, even given these caveats, the general picture is similar to those that ignore price growth. The main impact is to reduce the costs in high-wage high price-growth places in the South East of England on the right of the picture.

In Figure 3, we show the picture using the alternative method described in section 4.9 where we plot the log housing price index against the housing-share-weighted log earnings index. Again we see the same general pattern, although relative costs are lower in high-price/high-wage areas, and the greatest deviations from the 45-degree line are seen in the low-wage rural areas on the left. Although this method relaxes the assumption that workers do not adjust their consumption of housing as they move from low to high house price areas, it imposes the alternative restriction of a constant share of housing in total expenditure. There is no formal way of testing which of these assumptions is correct, although it should be noted that some simple evidence counts against the constant-share assumption: The mean share of housing in expenditure from the EFS data is 31%, but ranges from 26% in the North East to 37% in London. In any case, as pointed out in section 4.9 the two methods are equivalent for marginal changes, and we show below that the implied quality of life indices using all the above methods are very highly correlated.

Figure 3: Association between housing costs and net earnings.
Log-log model assuming constant housing shares

Log housing price index and log earnings index, weighted by 1/share of housing in total expenditure
Share = 0.31
Coefficient 0.707 (0.154)



5.2. Quality of life rankings

As discussed in section 3, the deviation of each point above the theoretical spatial equilibrium (45 degree) line can be interpreted as a measure of willingness to pay for the non-wage amenities associated with each area, or 'quality of life'. Similarly, deviations below the line can be interpreted as the compensation for the non-wage disamenities provided by each area. This 'quality of life' measure can be computed from the difference between housing costs and wages. We report the 'quality of life' indices in various ways. In Appendix B we tabulate the indices using the same assumptions used to produce Figure 2 and Figure 3. In Table 1 we report the correlations between the indices computed under different assumptions (interest-based, myopic, user-costs, constant share), and some statistics summarising the urban-rural differences. Figure 4 and Figure 5 map the housing cost-earnings differentials, or quality of life estimates.

Looking specifically at the numbers in Appendix B, Columns 1-3 are the vertical deviations of each point in Figure 2 from the dotted 45 degree line. The areas below the 45 degree line (with negative £000s values in Appendix B) are those which are valued least, given the earnings potential, and those above the 45 degree line are valued most (with positive £000s values in Appendix B). Similarly, Column 4 in Appendix B reports the deviations from the 45 degree line in the log-log plot of Figure 3. As was evident from Figure 2, there is a mixture of both low wage rural areas (Chichester, Dorset Coast) and high-wage urban areas (London, Brighton) in the top ranked areas on both the interest-only and myopic costs measures, with high-wage urban areas more prevalent. In the user-cost and constant-share (log-log) based indices, the rural areas dominate the top rankings. These notable differences in the upper end of the rankings are not very representative of the general picture: Table 1 shows that the rank correlations between all these indices is very high, between 0.90 and 0.99. Overall there is no difference in the rankings between urban and rural areas, as shown by the reported mean ranks and the rank-sum tests (the rank-sum test, tests for differences between the mean rank in the two groups). In all cases apart from the 'myopic' housing cost case, rural areas are slightly higher ranked than urban areas, but the difference is not statistically significant.

Table 1: Rank correlations between quality of life indices.

Rank correlations	Interest	Myopic	User	Share
Interest	1.0000			
Myopic	0.9947	1.0000		
User	0.9284	0.9041	1.0000	
Share	0.9886	0.9782	0.9370	1.0000
Rural urban comparison				
Rural mean rank	77.9	79.7	73.9	76.8
Urban mean rank	80.1	78.3	84.0	81.2
Ranksum test	p = 0.75	p = 0.850	p = 0.16	p = 0.55

The prevalence of towns around London like Slough, Tunbridge and Luton high up in the interest-based and myopic rankings in Appendix B gives some cause for concern, in that these places are not, by reputation, obvious candidates as high quality of life locations (Tunbridge is a possible exception). A potential explanation is that prices in these locations are inflated by potential commuting opportunities to London, given that our TTWA-based labour market areas are not completely self contained. To investigate this we re-estimated the LMA earnings estimates taking into account adjacent LMAs, such that, for example, the expected earnings in Slough becomes a weighted average of earnings in Slough and neighbouring LMAs. We use inverse distance weights, based on straight-line distances between the LMA centroids. This adjustment makes very little difference to the patterns or rankings (see Appendix C), suggesting that these locations are genuinely attractive for reasons other than the expected labour market or commuting opportunities.

The map in Figure 4 shows the spatial distribution of the interest-based quality of life indices (including Stamp Duty, maintenance, council tax). There is a general north-south trend, and a predominance of high values in the southern and south west coastal areas is the most striking feature of this map. The picture is similar in the maps of Figure 5 which shows the alternative cost definitions. In the next section we go on to analyse what factors lie behind these spatial patterns.

Figure 4: Housing cost minus earnings differentials for GB Labour Market Areas. Work-place based wages, interest only plus maintenance, council tax, stamp duty, 1.7 worker households

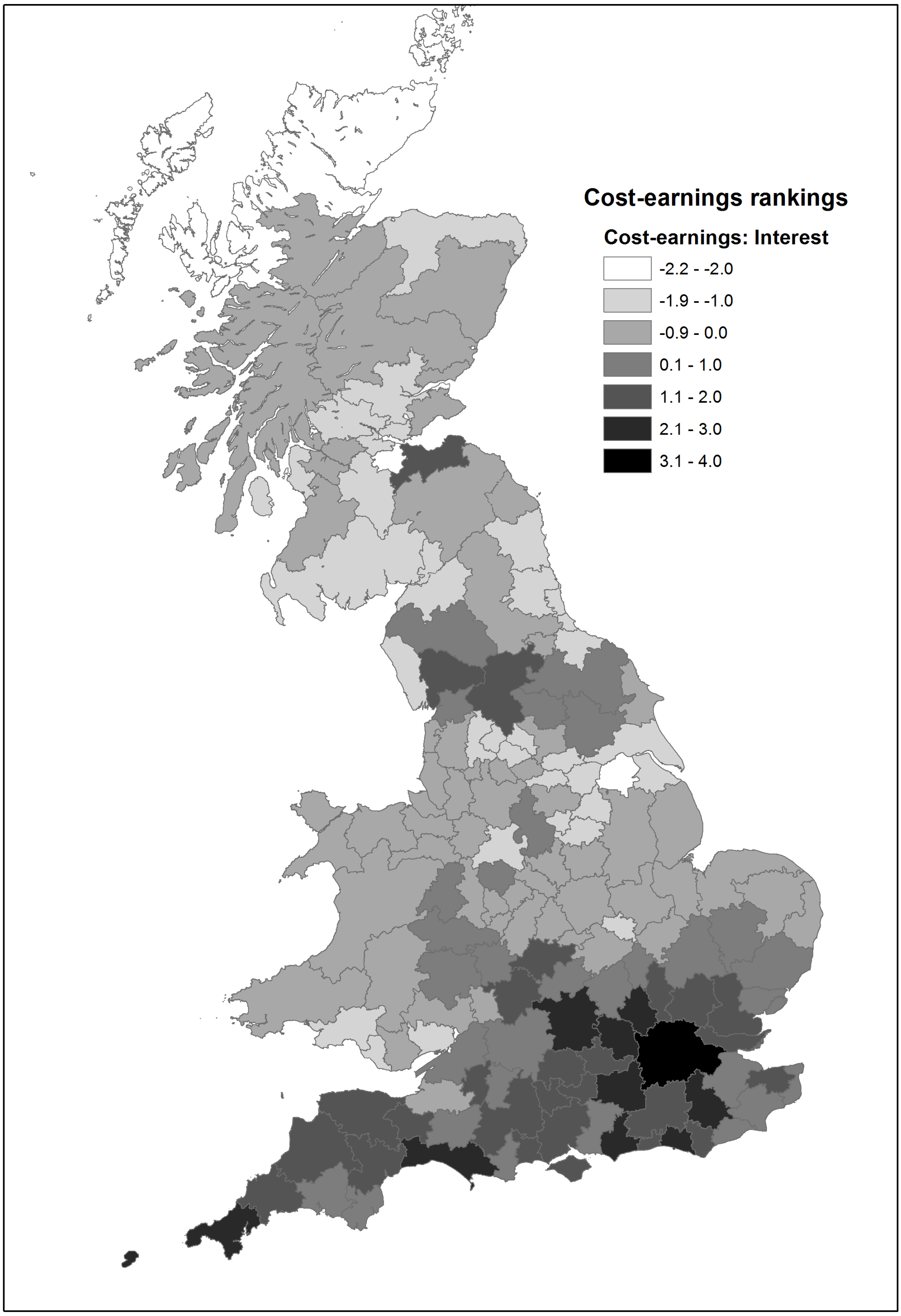
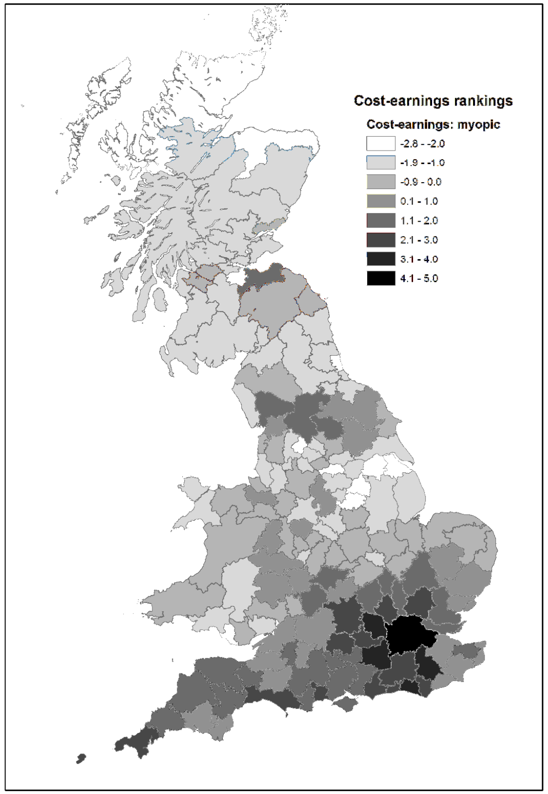
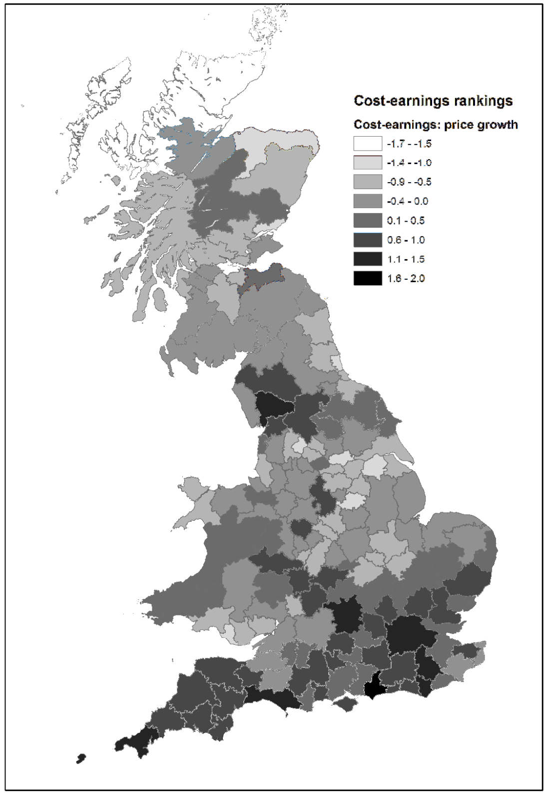


Figure 5: Quality of life differentials for GB Labour Market Areas. Alternative cost and wage definitions

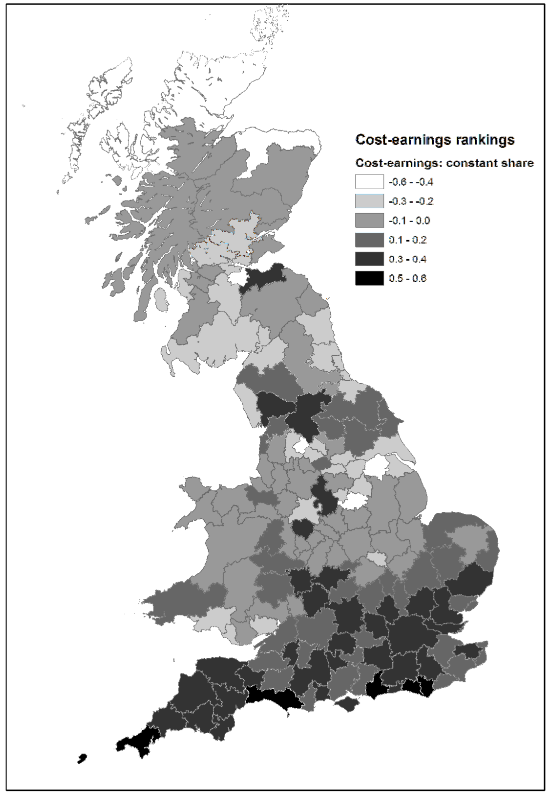
Myopic housing costs



User costs with price growth



Constant housing share-based



5.3. Valuing labour market area amenities

As the final part of this analysis, we take the 'quality of life' values discussed above (and reported in Appendix B) and regress these on amenities measured at the LMA level (described in Section 4.7). The results are reported in Table 2, for the interest-based, myopic, user-cost and constant share based indices. These regressions are based on data for England and Wales only, because no crime data is available for Scotland. All amenity variables are standardised to have a unit standard deviation. The coefficients in Columns 1-3 show the £1000s associated with a one-standard deviation change in each amenity. The coefficients in Column 4 show the association in terms of log-differences for a one standard deviation change, multiplied by 100, so indicate the approximate percentage effect on the overall amenity value. There are clearly many amenities that could be included here, and we focus on those that have precedents in the literature, plus novel ones that theory would suggest are important. The regressions are intended to be descriptive, and we are not always confident about placing a 'causal' interpretation on them. There are also collinearity issues, so some of the coefficients are quite large but imprecisely measured.

Looking down the rows, the results in the first two Columns of Table 2 are very similar to each other. The amenities that appear to dominate the interest-based and myopic indices in terms of magnitude and significance are employment accessibility, rainfall intensity, particulate pollutants, cultural amenities (museums), crime and a residual general north-south, west-east trend (as captured by the Northings and Eastings coordinates). These coefficients have plausible signs. The coefficient on woodland land cover is also marginally significant. Average terrain slope has a significant positive association with quality of life, which could reflect attractiveness of rugged landscapes. However, the interpretation of the effect of terrain is complicated by the interaction of the constraining effects on housing supply (Hilber and Vermeulen 2010) with the environmental quality and recreational attractions in mountain areas.

The positive coefficient on employment accessibility is consistent with the idea that low commuting costs to neighbouring LMAs are an important contributor to local amenity value, but other transport-related variables in the regression do not seem important. The significance of employment accessibility, along with jobs-per-household in the LMA, also indicates that availability of employment affects housing costs, conditional on wages. This is not too surprising, given we have made no adjustment for the probability of being out of work, other than that implied by our definition of 1.7-worker households. Climate appears to be important (as is found in similar work in the US) although it is difficult to separate out the contribution of specific climate components given they tend to be quite highly correlated. Rainfall dominates amongst the weather-related variables in the specifications shown in Table 2, and is, unsurprisingly, a disamenity. Rainfall intensity is measured here as the amount of precipitation on days when there is any rain (>1mm) averaged from 1961-1990 so is a measure of how wet it is on wet days, rather than how many wet days there are in the year. Unlike in US work, temperature related factors do not seem to matter, and nor does sunshine hours if we include that instead. Of course, the range of climactic variation across Britain on these two dimensions is much less than in the US.

The two pollution measures we report here are N02 (nitrogen dioxide) and PM2.5 (particulate matter <2.5μm in diameter). PM2.5 dominates as the negative amenity in this regression and is the single most important factor (aside from general North South trends) in terms of magnitude and significance of its statistical relationship with cost-earnings differentials (PM10 data and NOX data yields similar results). Part of this effect is probably due to correlation of PM2.5 concentrations with other disamenities, such as visual or aural proximity to main roads and industrial sites given that the pollution measures are modelled from these sources. The concentration of pollutants could also be capturing more general spatial trends. As can be seen in the map in Appendix D, there is a high concentration of PM2.5 towards the South East of England, with very low concentrations in remote rural areas. This is to be expected given that roads are the primary sources of PM2.5 concentration.

However, looking at the coefficients on the south-north trends in the regression table (Northings) reveals that whilst pollutants tend to lower housing costs relative to earnings in the south, there remain strong north-south positive trends. In other words, whilst remoteness from the south tends to lower housing costs for a given level of earnings, pollutant concentrations work in the opposite direction.

Table 2: Valuations of amenities based on housing cost-earnings differentials (England and Wales only). OLS regressions.

	Interest-based	Myopic	User costs	Fixed share (logs)
Employment accessibility	**0.503 (0.224)	***0.762 (0.289)	0.158 (0.151)	5.81 (5.55)
Jobs per household	**0.174 (0.086)	**0.218 (0.108)	0.088 (0.058)	*3.21 (1.70)
Urban land cover	0.218 (0.185)	0.259 (0.237)	0.116 (0.122)	0.26 (4.56)
Woodland land cover	*0.127 (0.077)	*0.171 (0.096)	0.089 (0.052)	-0.14 (1.95)
Grassland land cover	-0.038 (0.144)	-0.088 (0.179)	-0.003 (0.095)	0.03 (3.48)
Water land cover	-0.094 (0.087)	-0.158 (0.106)	-0.009 (0.060)	-1.97 (1.85)
Length of coastline	0.001 (0.131)	0.049 (0.158)	-0.026 (0.091)	0.97 (3.05)
Area of national park	0.105 (0.086)	0.149 (0.104)	0.008 (0.057)	**5.02 (0.02)
Length of rivers	-0.110 (0.083)	-0.149 (0.102)	-0.042 (0.057)	-1.72 (1.71)
Rainfall	***-0.361 (0.129)	***-0.400 (0.155)	***-0.288 (0.093)	*-6.25 (3.76)
Heating days	0.185 (0.597)	0.166 (0.743)	0.415 (0.379)	-2.93 (15.50)
Cooling days	-0.116 (0.264)	0.011 (0.334)	-0.235 (0.177)	0.61 (5.86)
NO2 mean	-0.012 (0.288)	0.032 (0.362)	-0.031 (-0.187)	2.71 (7.03)
Particulate matter 2.5 (mean)	***-0.904 (0.278)	***-1.295 (0.349)	**-0.358 (0.175)	***-17.62 (6.48)
Mean elevation	-0.451 (0.379)	-0.524 (0.477)	-0.386 (0.212)	-1.37 (10.09)
Mean slope	**0.473 (0.204)	**0.569 (0.256)	**0.288 (0.128)	3.38 (4.98)
Total length primary roads	-0.014 (0.095)	-0.032 (0.120)	0.000 (0.062)	0.21 (2.56)
Mean speed on primary roads	0.006 (0.105)	0.003 (0.129)	0.006 (0.069)	-2.85 (2.14)
Rail stations	0.051 (0.096)	0.068 (0.118)	0.037 (0.072)	1.50 (2.11)
Motorway junctions	-0.037 (0.080)	-0.033 (0.100)	-0.024 (0.055)	0.08 (2.18)
Museums	***0.184 (0.069)	***0.222 (0.086)	**0.104 (0.044)	**3.73 (1.54)
Crime	***-0.390 (0.121)	***-0.492 (0.152)	**-0.187 (0.078)	***-9.96 (2.53)
Eastings	**0.393 (0.190)	**0.520 (0.233)	0.124 (0.125)	5.39 (4.73)
Northings	***-1.425 (0.478)	***-1.754 (0.602)	***-0.955 (0.306)	***-27.29 (13.05)
R2	0.740	0.766	0.569	0.695

Table reports coefficients and standard errors (robust to heteroscedasticity) from regression of estimated housing cost minus net earnings differentials at LMA level (138 observations). Coefficients in Columns 1-3 are in £1000s. Coefficients in Column 4 are log-differentials x100. All amenity variables standardised to unit standard deviation. *** significant at 1%, ** at 5% * at 10%.

The number of museums per person suggests a positive association with cultural amenities, although admittedly this could be picking up the effects of other city attributes. Crime rates - which are also high in urban areas - tend to depress prices relative to earnings. Overall, the pattern of significant coefficients is plausible given what we would expect to be the main amenities and disamenities. Other amenities considered in, such as road congestion and terrain are only weakly linked to cost-earnings differentials and quality of life.

The north-south and west-east positive trends are open to interpretation. They may reflect omitted climate or other environmental variables, be related to peripherality from London, be proxying some other unobserved amenity that is more prevalent in the south east. In addition, a less elastic supply of housing may inflate the value of amenities in south east. Either way it is evident that there remains a strong north-south trend in cost-earnings differentials, and implied quality of life, that are not explained by the basic land cover and amenity variables in this analysis.

When we turn to the rankings based on user-costs (Column 3 in) and the constant housing share assumption, we find some similar patterns. Many of the effects that were strongest and highest magnitude in Columns 1 and 2 remain significant (rainfall, particulates, slope, museums, crime, north-south trends). Employment accessibility and job density are not important in this specification, nor are west-east trends. A similar picture emerges in Column 4, with the addition of a significant coefficient on the land area designated as National Park.

On balance though, the findings in Table 2 paint a fairly coherent picture, in which rainfall, particulate pollutants, city-related amenities and crime emerge as the dominant amenity variables, alongside strong residual north-south trends.

6. Conclusions

This paper describes the relationship between housing costs and earnings across British labour market areas. We have extended existing work in this field by computing net-of-tax earnings and annual housing costs from micro data on housing transactions and individual earnings. Our work goes beyond what has been done before for Britain (and elsewhere) in a number of ways. We have adjusted costs for differences in housing structure between labour market areas, and adjusted earnings for differences in worker characteristics caused by sorting of workers across areas. In particular, ours, as far as we are aware, is the first study of this type to estimate labour market earnings differentials based on inter-labour market movers in an individual fixed effects regression. We have developed a detailed set of area-level amenities for use in the analysis. Our study also considers a period of 10 years and is built on a sample of over 1.5 million workers and 880,000 housing transactions.

Empirically, quality-adjusted housing costs tend to rise one-for-one with the skill-adjusted earnings that an individual worker could expect as they move from a one labour market area to another (based on our preferred specifications) - at least in so far as these moves are between places in the middle of the earnings and housing cost distribution. The implication is that nominal earnings disparities are uninformative about the real earnings disparities and disparities in consumption between workers in different areas, because wage gains areas are, on average, offset by rising costs. However, the detail of the relationship is more nuanced. There are non-linearities with high cost-earnings differentials at both the bottom (predominantly remote rural) and top (predominantly core urban) of the earnings distribution giving rise to a U-shaped relationship, and implying that these labour markets appear to be high-cost places to live and work. Even then, it should be borne in mind that the these places have high housing costs because they are popular places to live and work, so the high costs may not imply any economic disadvantage to those who live and work there.

Interpreting cost-earnings differentials as valuing 'quality of life, we find only slight differences between rural and urban areas in the rankings. Employment accessibility, and cultural amenities (museums) emerge as the most important amenities, while crime, rainfall intensity, and particulate pollutants (or their sources) are the main disamenities.

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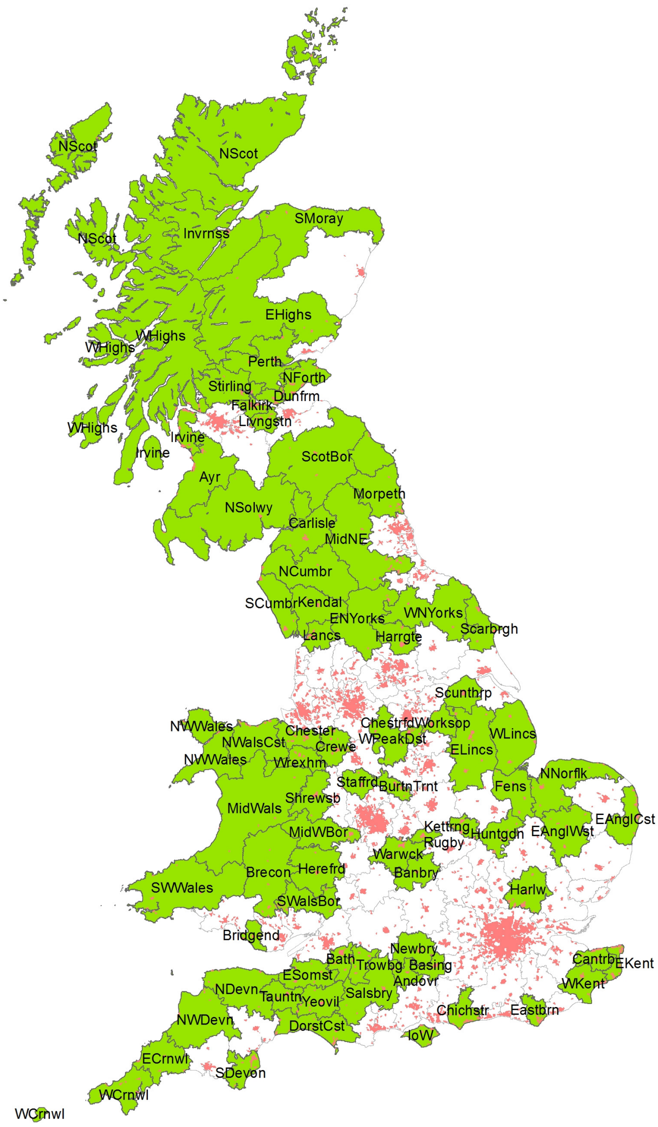
Appendix A: Labour Market Area definitions

Rural TTWAs and aggregates



Primary urban TTWAs

Appendix B: Labour Market Area rankings

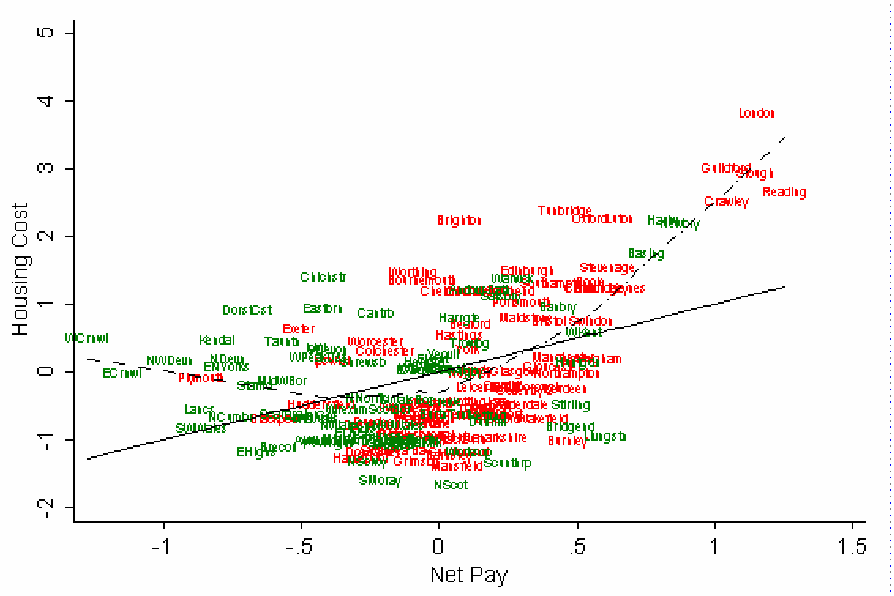
	Interest		Myopic		User Cost		Constant share	
rank	area	cost	area	cost	area	cost	area	Cost
1	London	3.26	London	4.56	Chichstr	1.83	WCrnwl	0.56
2	Brighton	2.72	Guildford	3.49	WCrnwl	1.46	Chichstr	0.51
3	Guildford	2.48	Brighton	3.49	Tunbridge	1.34	DorstCst	0.46
4	Tunbridge	2.43	Slough	3.25	DorstCst	1.20	Brighton	0.46
5	Chichstr	2.37	Tunbridge	3.23	Eastbrn	1.20	Eastbrn	0.41
6	Slough	2.26	Oxford	2.92	Oxford	1.19	NWDevn	0.39
7	WCrnwl	2.23	Chichstr	2.84	London	1.15	ECrnwl	0.39
8	Oxford	2.16	Luton	2.83	Kendal	1.06	Worthing	0.39
9	DorstCst	2.07	Crawley	2.73	ECrnwl	1.04	Tunbridge	0.38
10	Luton	2.06	Reading	2.63	Worthing	1.02	Kendal	0.38
11	Worthing	1.99	Harlw	2.57	Guildford	1.02	Bournemouth	0.35
12	Crawley	1.87	Worthing	2.49	ENYorks	0.99	London	0.35
13	Eastbrn	1.85	WCrnwl	2.42	Bournemouth	0.97	Exeter	0.33
14	Harlw	1.81	DorstCst	2.39	NDevn	0.96	Oxford	0.32
15	Bournemouth	1.77	Newbry	2.36	Slough	0.95	Tauntn	0.32
16	Reading	1.74	Bournemouth	2.24	MidWBor	0.95	NDevn	0.32
17	Kendal	1.66	Eastbrn	2.19	Warwck	0.95	Cantrb	0.32
18	Newbry	1.63	Chelmsford	1.91	Brighton	0.95	Luton	0.30
19	Chelmsford	1.49	Warwck	1.85	Newbry	0.94	Chelmsford	0.30
20	NWDevn	1.45	Andovr	1.85	Staffrd	0.88	ENYorks	0.30
21	ECrnwl	1.43	Edinburgh	1.83	Luton	0.87	Guildford	0.30
22	Cantrb	1.43	Kendal	1.83	Exeter	0.86	Plymouth	0.29
23	Andovr	1.43	Basing	1.80	NWDevn	0.85	Andovr	0.28
24	Exeter	1.41	Cantrb	1.74	Cheltenham	0.84	Slough	0.27
25	Warwck	1.38	Stevenage	1.72	Tauntn	0.84	IoW	0.27
26	Edinburgh	1.32	Cheltenham	1.69	Andovr	0.80	Cheltenham	0.26
27	Cheltenham	1.28	Exeter	1.64	Chelmsford	0.80	Warwck	0.26
28	Tauntn	1.27	Southend	1.64	Cantrb	0.76	Harlw	0.25
29	NDevn	1.24	Bath	1.60	Lancs	0.76	Southend	0.23
30	Southend	1.22	NWDevn	1.53	Harlw	0.74	Edinburgh	0.23
31	Basing	1.21	Salsbry	1.52	Plymouth	0.74	SDevon	0.23
32	Stevenage	1.19	Southampton	1.51	Worcester	0.69	Bath	0.22
33	Bath	1.19	ECrnwl	1.45	Ipswich	0.69	Crawley	0.22
34	ENYorks	1.18	Tauntn	1.44	IoW	0.68	Salsbry	0.22
35	Salsbry	1.13	Poole	1.39	WPeakDst	0.65	Newbry	0.22
36	IoW	1.08	NDevn	1.32	Crawley	0.61	Ipswich	0.22
37	Southampton	1.06	Portsmouth	1.30	NCumbr	0.60	Worcester	0.22
38	Plymouth	0.95	IoW	1.22	SDevon	0.60	WPeakDst	0.22
39	Portsmouth	0.94	Cambridge	1.21	Salsbry	0.56	Staffrd	0.21
40	Poole	0.94	ENYorks	1.20	Portsmouth	0.54	MidWBor	0.20
41	SDevon	0.89	Milton Keynes	1.17	Basing	0.48	Stevenage	0.20
42	WPeakDst	0.88	Harrgte	1.14	Bedford	0.46	Portsmouth	0.19

43	Harrgte	0.87	Bedford	1.09	Southend	0.45	Southampton	0.19
44	Worcester	0.85	SDevon	1.03	Shrewsb	0.44	Bedford	0.19
45	Bedford	0.85	Worcester	1.00	Reading	0.44	Basing	0.19
46	Cambridge	0.79	Banbry	0.98	Blackpool	0.41	Colchester	0.18
47	Ipswich	0.77	WPeakDst	0.96	Edinburgh	0.41	Reading	0.18
48	Milton Keynes	0.75	Maidstone	0.95	Stevenage	0.41	Harrgte	0.17
49	Colchester	0.69	Plymouth	0.93	Southampton	0.34	Lancs	0.16
50	Maidstone	0.67	Hastings	0.88	Colchester	0.29	Hastings	0.15
51	Hastings	0.67	Ipswich	0.83	Herefrd	0.26	Maidstone	0.15
52	Banbry	0.65	Colchester	0.80	Huddersfield	0.26	Cambridge	0.14
53	Staffrd	0.62	Bristol	0.67	Maidstone	0.25	Poole	0.14
54	MidWBor	0.61	Trowbg	0.58	Trowbg	0.25	Shrewsb	0.14
55	Shrewsb	0.51	Shrewsb	0.57	Bath	0.24	Milton Keynes	0.13
56	Trowbg	0.43	MidWBor	0.57	Hastings	0.23	Trowbg	0.11
57	Lancs	0.42	Staffrd	0.55	Poole	0.22	Banbry	0.11
58	Bristol	0.40	Swindon	0.47	Harrgte	0.22	NCumbr	0.10
59	Yeovil	0.32	Yeovil	0.42	Chester	0.22	EKent	0.09
60	EKent	0.31	EKent	0.39	Scarbrgh	0.21	Yeovil	0.08
61	Herefrd	0.26	WKent	0.32	SWWales	0.20	Herefrd	0.08
62	Swindon	0.22	York	0.31	Milton Keynes	0.19	Bristol	0.08
63	York	0.19	Herefrd	0.31	Cambridge	0.18	EAnglWst	0.07
64	NCumbr	0.16	Lancs	0.23	Rugby	0.16	York	0.06
65	EAnglWst	0.15	EAnglWst	0.16	EAnglWst	0.15	ESomst	0.04
66	WNYorks	0.13	WNYorks	0.16	EHighs	0.15	Chester	0.04
67	WKent	0.11	ESomst	0.06	EAnglCst	0.10	Swindon	0.04
68	Chester	0.05	Chester	0.05	MidWals	0.09	Scarbrgh	0.04
69	ESomst	0.04	Rugby	-0.07	WNYorks	0.07	Huddersfield	0.04
70	SWWales	-0.01	NCumbr	-0.09	Banbry	0.07	WNYorks	0.03
71	Scarbrgh	-0.05	Norwich	-0.14	NNorflk	0.03	Blackpool	0.03
72	Rugby	-0.07	Leeds	-0.24	Yeovil	0.02	SWWales	0.03
73	Huddersfield	-0.09	Huddersfield	-0.25	NSolwy	0.01	EAnglCst	0.02
74	Blackpool	-0.12	NNorflk	-0.26	EKent	0.00	NNorflk	0.02
75	NNorflk	-0.14	Scarbrgh	-0.27	Swindon	0.00	WKent	0.01
76	Norwich	-0.15	SWWales	-0.29	ESomst	-0.01	Rugby	0.01
77	EAnglCst	-0.18	Blackpool	-0.37	NForth	-0.03	Norwich	0.00
78	Leeds	-0.25	Manchester	-0.38	SWalsBor	-0.06	Leeds	-0.01
79	MidWals	-0.33	EAnglCst	-0.40	Wrexhm	-0.07	MidWals	-0.01
80	Wrexhm	-0.35	Huntgdn	-0.41	Leeds	-0.09	Wrexhm	-0.03
81	Glasgow	-0.39	Glasgow	-0.43	ELincs	-0.12	SWalsBor	-0.05
82	SWalsBor	-0.40	Gloucester	-0.43	Glasgow	-0.12	Glasgow	-0.05
83	Manchester	-0.44	Birmingham	-0.47	Preston	-0.13	ScotBor	-0.05
84	Huntgdn	-0.46	Wrexhm	-0.54	NWalsCst	-0.14	Leicester	-0.07
85	Gloucester	-0.47	SWalsBor	-0.56	Wirral	-0.21	Manchester	-0.07
86	Wirral	-0.49	Leicester	-0.57	Wolves	-0.21	Wirral	-0.08
87	Leicester	-0.49	MidWals	-0.57	MidNE	-0.22	Gloucester	-0.09
88	Birmingham	-0.54	Northampton	-0.62	Walsall	-0.22	Walsall	-0.09

89	ScotBor	-0.54	Wirral	-0.68	Carlisle	-0.22	Huntgdn	-0.09
90	Walsall	-0.54	Crewe	-0.69	Crewe	-0.23	Telford	-0.10
91	Crewe	-0.54	Walsall	-0.70	Darlington	-0.23	Birmingham	-0.10
92	Telford	-0.57	ScotBor	-0.72	Bristol	-0.24	Crewe	-0.10
93	Preston	-0.59	Telford	-0.72	Fens	-0.25	Cardiff	-0.10
94	Northampton	-0.62	Cardiff	-0.75	Brecon	-0.27	Northampton	-0.11
95	EHighs	-0.63	Peterborough	-0.78	Norwich	-0.27	Preston	-0.11
96	Ayr	-0.64	Preston	-0.78	York	-0.27	Brecon	-0.11
97	Dundee	-0.64	Coventry	-0.81	Telford	-0.31	Fens	-0.11
98	Fens	-0.67	Nottingham	-0.90	Rochdale	-0.32	Wolves	-0.11
99	NWalsCst	-0.67	Wolves	-0.91	Leicester	-0.33	Dundee	-0.12
100	Cardiff	-0.68	Dundee	-0.92	WLincs	-0.34	Ayr	-0.12
101	Brecon	-0.68	Fens	-0.95	Warrington	-0.35	ELincs	-0.12
102	Wolves	-0.69	NWalsCst	-0.95	WKent	-0.36	NWalsCst	-0.12
103	Peterborough	-0.70	Ayr	-0.99	Nottingham	-0.39	Peterborough	-0.13
104	ELincs	-0.71	ELincs	-1.02	Manchester	-0.40	Darlington	-0.13
105	Coventry	-0.72	Darlington	-1.02	Invrnss	-0.40	Coventry	-0.13
106	Darlington	-0.75	BurtnTrnt	-1.02	Ayr	-0.40	Nottingham	-0.14
107	WLincs	-0.75	Aberdeen	-1.05	Coventry	-0.41	WHighs	-0.14
108	Nottingham	-0.76	Brecon	-1.06	SCumbr	-0.42	NForth	-0.15
109	WHighs	-0.77	Derby	-1.07	Bolton	-0.43	Warrington	-0.15
110	MidNE	-0.78	Liverpool	-1.08	Stoke-on-Trent	-0.43	WLincs	-0.15
111	BurtnTrnt	-0.82	Sheffield	-1.09	ScotBor	-0.44	Dudley	-0.15
112	Warrington	-0.85	WLincs	-1.09	Chestrfd	-0.45	Sheffield	-0.15
113	Sheffield	-0.87	Warrington	-1.10	Dudley	-0.47	Derby	-0.16
114	NForth	-0.90	Dudley	-1.10	Middlesbrough	-0.49	Invrnss	-0.16
115	Derby	-0.90	EHighs	-1.10	Cardiff	-0.51	EHighs	-0.16
116	NWWales	-0.90	MidNE	-1.13	Livngstn	-0.52	BurtnTrnt	-0.16
117	Liverpool	-0.91	WHighs	-1.15	Northampton	-0.52	Bolton	-0.17
118	Dudley	-0.91	NWWales	-1.16	Swansea Bay	-0.52	MidNE	-0.18
119	Rochdale	-0.92	Rochdale	-1.18	Doncaster	-0.52	Rochdale	-0.18
120	Bolton	-0.93	Bolton	-1.19	Hartlepool	-0.53	Aberdeen	-0.18
121	Invrnss	-0.93	Calderdale	-1.25	Sheffield	-0.53	NWWales	-0.18
122	Aberdeen	-0.93	Kettrng	-1.26	Birmingham	-0.54	Liverpool	-0.19
123	Kettrng	-1.05	Invrnss	-1.26	BurtnTrnt	-0.54	Calderdale	-0.21
124	Chestrfd	-1.05	NForth	-1.28	Huntgdn	-0.56	Kettrng	-0.21
125	Calderdale	-1.07	Newcastle	-1.31	Liverpool	-0.57	Newcastle	-0.21
126	Newcastle	-1.09	Chestrfd	-1.40	Derby	-0.59	Carlisle	-0.22
127	SCumbr	-1.09	Newport	-1.42	Gloucester	-0.60	Newport	-0.22
128	Carlisle	-1.10	Stirling	-1.43	WHighs	-0.61	Chestrfd	-0.22
129	Middlesbrough	-1.11	Middlesbrough	-1.43	Calderdale	-0.62	Middlesbrough	-0.22
130	Morpeth	-1.11	SCumbr	-1.44	Newcastle	-0.64	Stoke-on-Trent	-0.23
131	Perth	-1.16	Morpeth	-1.47	Peterborough	-0.64	Falkirk	-0.23
132	Stoke-on-Trent	-1.19	Carlisle	-1.47	Grimsby	-0.66	SCumbr	-0.24
133	Newport	-1.19	Bradford	-1.50	Perth	-0.67	Irvine	-0.24
134	Irvine	-1.20	Perth	-1.51	Aberdeen	-0.69	Dunfrm	-0.25

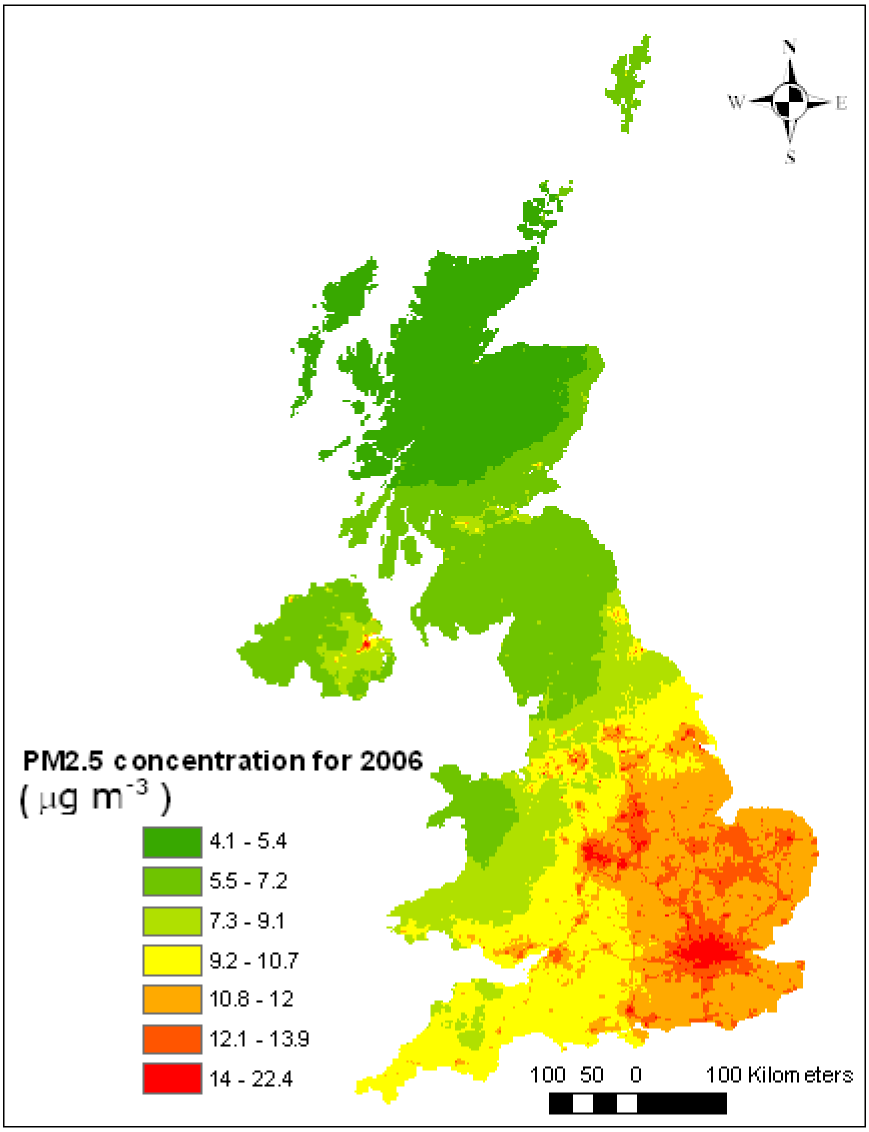
135	Dunfrm	-1.21	Dunfrm	-1.51	Hull	-0.73	Morpeth	-0.25
136	Stirling	-1.22	Stoke-on-Trent	-1.52	Newport	-0.73	Perth	-0.25
137	Hartlepool	-1.23	Irvine	-1.59	Kettrng	-0.75	Stirling	-0.26
138	Doncaster	-1.25	Hull	-1.64	NWWales	-0.75	Bradford	-0.26
139	Bradford	-1.25	Falkirk	-1.65	Worksop	-0.77	Hull	-0.27
140	Falkirk	-1.29	Doncaster	-1.65	Morpeth	-0.77	Doncaster	-0.27
141	Hull	-1.29	Hartlepool	-1.67	Irvine	-0.78	Hartlepool	-0.27
142	Swansea Bay	-1.31	Wakefield	-1.71	Blackburn	-0.79	Swansea Bay	-0.28
143	NSolwy	-1.34	Swansea Bay	-1.72	Bradford	-0.79	Wakefield	-0.29
144	Blackburn	-1.38	Blackburn	-1.72	Lanarkshire	-0.80	NSolwy	-0.30
145	Wakefield	-1.48	NSolwy	-1.84	Dunfrm	-0.84	Blackburn	-0.31
146	Lanarkshire	-1.53	Lanarkshire	-1.89	Barnsley	-0.89	Lanarkshire	-0.32
147	Grimsby	-1.53	Grimsby	-1.99	Stirling	-0.89	Grimsby	-0.35
148	Worksop	-1.60	Worksop	-2.01	Mansfield	-0.96	Barnsley	-0.35
149	Sunderland	-1.66	Bridgend	-2.01	Sunderland	-0.97	Bridgend	-0.37
150	Barnsley	-1.67	Sunderland	-2.07	Wakefield	-1.04	Sunderland	-0.37
151	SMoray	-1.69	Barnsley	-2.10	Bridgend	-1.06	Worksop	-0.37
152	Bridgend	-1.72	SMoray	-2.27	SMoray	-1.08	SMoray	-0.42
153	Mansfield	-1.80	Mansfield	-2.27	Dundee	-1.09	Mansfield	-0.43
154	Burnley	-1.93	Burnley	-2.29	Scunthrp	-1.17	Burnley	-0.44
155	Scunthrp	-1.99	Livngstn	-2.38	Burnley	-1.33	Livngstn	-0.47
156	Livngstn	-2.02	Scunthrp	-2.45	Falkirk	-1.45	Scunthrp	-0.51
157	NScot	-2.16	NScot	-2.76	NScot	-1.67	NScot	-0.58

Appendix C: Adjusting for commuting

Interest only, allowing for inter-area commutes, by aggregation of LMA earnings using inverse distance weights: Coefficient 1.173 (0.219)	

Appendix D: Pollutant concentrations (PM2.5)

MAP 4 – $PM_{2.5}$ concentration for 2006 ($\mu g\ m^{-3}$)



Source: http://www.airquality.co.uk/.

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