Welfare Economics of Land Use Regulation

Paul Cheshire and Stephen Sheppard

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Abstract

Despite the pervasive nature of land use planning and land use regulation, evaluation of the costs and benefits of these policies has received only limited attention. This paper presents an empirical methodology, based on clear microeconomic foundations, for the evaluation of benefits and costs of land use planning. The technique is applied to the Town and Country Planning System of the UK. Evaluation is presented of gross benefits from several land use planning activities, the net costs of land use planning, and the distributional consequences of these policies. The results show that these welfare and distributional impacts are considerable.

1. Introduction

A central focus of economics is evaluation of the consequences of public policy. From Corn Laws to Airline regulation, the tools of the profession have been applied to determine the costs and benefits of acts of government. This continues to the present, with examples such as consideration of environmental regulation Hazilla and Kopp (1990), occupational safety regulation French (1988) and noise regulation Holland and Cross (1995). Curiously, one of the most pervasive forms of government regulation has received much less attention from economists: land use planning. While the theoretical properties of land use controls have received some attention[2], there are no studies which have estimated the net costs and distributional consequences.

Virtually every urban area in the developed world exercises some control over the use of land and the type or extent of residential building. Such regulation serves a variety of purposes: control of the spatial structure of residential development can reduce the cost of providing some local public goods and serve to isolate land uses which are likely to generate costly external effects; regulation of building types can serve to limit the deadweight loss from property taxation; regulation of land use can be a method of providing valued public goods and amenities by fiat rather than through imposition of taxes and purchase of land in particular uses.

Of course, the types of regulation which have been the subject of extensive analysis also serve a variety of goals and can reasonably be claimed to generate benefits as well as costs. The question of interest is not whether these public policies generate benefits, but rather what is the value of the benefit and how do these benefits compare with the costs associated with the policies. In this paper we develop and test an approach for such an evaluation of land use planning. We apply this method to evaluate (at least some of the) benefits and the net costs of land use planning, and the distributional incidence of these benefits and costs. The methodology is applied to the British Town and Country Planning System.

The British land use planning system is the archetype for one of the three main types of planning system that operate around the world; the others being the 'master planning' system of continental Europe and the zoning system of the USA. In the British system every action that legally constitutes development requires individual consideration by the planning authority of the local community.

Several previous papers[3] have shown that these systems of 'development control' act to restrict the supply of urban land by category of land use. The British and other land use planning systems generate benefits in the form of unpriced local public goods. Unlike some other public goods, these are not made available by imposing taxes on local residents and then using the proceeds to pay for production. Rather, they are produced by using the power of the state to require land to be used in particular ways, or neighbourhoods to be of a particular type. The absence of taxes does not imply the absence of costs. These policies can generate significant changes in land prices. This generates both welfare costs, measurable in terms of the equivalent variation associated with the price change, and distributional effects.

This paper draws on previous results which have estimated implicit prices and identified the structure of demand for land and planning benefits to develop a methodology for quantifying the net welfare and distributional impacts this system of land use planning can have. Using analysis of land values and housing markets in cities chosen to represent the full range of possible levels of planning restrictiveness, we calculate the changes in land values attributable to the planning system. This permits us to calculate the equivalent variation in income associated with the policies, and to assess the effective distributional consequences.

Such analysis has been undertaken for many of the other productive activities of local governments, but has not generally been undertaken for land use planning because of the lack of explicit taxes and payments. We view this paper as providing the first results of this sort for the British system, and believe that the methodology might be quite useful in assessing the implications of land use planning on the distribution of welfare and equity in other contexts.

All planning systems work to some extent to provide local amenities without collecting taxes to pay for them. Thus, in principle, the techniques we employ should be applicable to analysis of other types of planning systems. To the extent that the distribution of burdens and benefits arising out the planning system differs from that associated with local tax structures, our analysis can also shed light on the distributional consequences of recent legal debates concerning 'takings' in the U.S., and the associated proposals to provide greater compensation (obtained presumably from tax revenues) to land owners whose property values are affected by planning and environmental policies.

1.1. Outline approach

The methodology we implement proceeds through a series of straightforward steps. We begin by identifying a structurally and geographically comparable pair of urban areas which appear to represent extremes, or near extremes, in the operation of land use planning constraints. For each urban area, sample data concerning the housing market is collected, including land, location, neighbourhood amenities, and incomes of households occupying the houses in the sample. An hedonic price function and demand system is estimated for each urban area which permits the construction of an expenditure function for consumers in each city. Using the expenditure function we estimate the utility level experienced by a 'typical' household in each city.

Taking this average household as representative of all households in each urban area, we use the standard characterization of land market equilibrium to determine the extent to which the local planning authority makes land available for residential use in each city, and use observed patterns of residential development to determine the innermost and outermost extent of residential land use

To estimate the gross benefits of land use planning, we use the demand system to determine the 'reservation price' for each amenity attributable to the planning system by calculating the price at which demand for the good would be reduced to zero. We can then estimate gross benefit to each household by calculating the variation in income associated with increasing the price of each amenity to the reservation price.

Estimation of the net costs of land use planning is somewhat more complex, since we must examine not only the change in benefits resulting from a change in planning regime (again using the demand system) but also the costs. The costs of land use planning come primarily in the form of increased prices for residential

Development Type	Darlington	Hull	Norwich	Oxford	Reading
			Acceptance Rates		
Minor Residential	.80	.78	.70	.66	.52
Major Residential	.86	.78	.74	.78	.54
All Minor	.88	.84	.82	.78	.66
All Major	.82	.80	.80	.78	.62
			Application Rate		
Minor Residential	.045	.06	.085	.09	.095
Major Residential	.006	.008	.0055	.0105	.0125

Table 2.1: Planning data for select UK cities: 1982-83

land and hence for housing. We estimate the equilibrium land rents under alternative planning regimes and calculate the equivalent variation in income associated with the combined reduction in residential land prices and effective increase in the price of the amenities produced by the planning system.

This approach permits us to examine the distribution among households of costs and benefits, and to provide tentative answers concerning the efficiency of the land use planning system as implemented in the UK. We find that considerable value is attached to the amenities produced by the planning system. These amenities, however, come at a very high cost, and we estimate considerable net costs associated with the most restrictive planning regime. The distributional consequences of the land use planning system are seen to depend on which aspects of planning are being considered. Taken as a bundle, we find the planning system to be somewhat 'redistributive', generally comparable to other public sector provision of in-kind benefits.

2. The Data

2.1. Planning restrictiveness

The data for this study are drawn from two cities: Reading (located in Berkshire and one of the most prosperous local economies in the South of England) and Darlington (located in Durham and one of the most prosperous local economies in the North of England). Both are relatively stable, intermediate sized cities with an essentially monocentric structure, and therefore plausible cities to which to apply the standard urban economic location model. Reading and Darlington also represent very different planning regimes. For example, consider the information presented in table 2.1. The table presents information on the rate of residential planning applications and the acceptance rate of those applications for five English cities.

The data in the table show striking differences in the acceptance rates and application rates between the cities, with Reading being much more restrictive than Darlington. Reading is also subject to much greater pressure for development as indicated by the much higher application rates. Comparative analysis of the two urban areas thus affords the possibility to explore the economic consequences of significant differences in land use planning regimes.

2.2. Observed Characteristics

The samples were collected in the second and third quarters of 1984. The data are described in more detail in Cheshire and Sheppard (1995b). Approximately 350 structures in Darlington, and 490 in Reading were included but some observations had to be dropped because particular variables were missing.

While a variety of hedonic studies have been undertaken for UK cities, none of which we are aware have had access to data which included the amount of land included with each structure and/or the precise location. Without such information, of course, it is impossible to obtain estimates of land values or land rent gradients in the sense embodied in standard economic theory: that is land as pure space with accessibility. As was shown in Cheshire and Sheppard (1995b), since the value of neighbourhood amenities is largely capitalised into land values, the market price of cleared sites does not reflect the appropriate concept. Since the economic effects of land use planning are primarily experienced as changes in the equilibrium price of land, with consequent implications for housing prices and land development.

The samples collected for Reading and Darlington include location, land area, plus a variety of structure and neighborhood characteristics. Table A.1 in the appendix provides a list of variables used in the estimation of the hedonic and the subsequent analysis of demand, along with brief descriptions.

The mean values and standard deviations for these variables are presented in table A.2. Darlington is a city with lower average incomes and significantly less costly housing than Reading. It is also smaller, with a built-up area consisting of about 36,000 households compared to Reading's 80,000.

3. Structure of Demand

Our analysis builds upon the previous work Cheshire and Sheppard (1995b), Cheshire and Sheppard (1995a) which obtained for these two cities estimates of hedonic prices and the structure of demand for housing and neighbourhood characteristics. Here we summarize those results.

3.1. Hedonic price function and land rents

Using the data described above, we estimate characteristics prices by estimating the coefficients of a 'Box-Cox' hedonic price function. We allow three different 'transformation parameters': one for the structure price, one for land area, and one for all other non-dichotomous variables. The final hedonic price function to be estimated is given by:

$$\frac{p^{\Psi}-1}{\Psi} = K + \sum_{i\in D} \beta_i \cdot q_i + \sum_{j\in C} \beta_j \cdot \left(\frac{q_j^{\lambda}-1}{\lambda} \right) + r(x,\theta) \cdot \frac{L^{\xi}-1}{\xi} \tag{3.1}$$

where:

p	=	rentalised price of structure
q_i, q_j	=	structure or location specific characteristics
$K, \beta_i, \beta_j, \psi, \lambda, \xi$	=	parameters to be estimated
L	=	quantity of land included with structure
D	=	set of indices of characteristics which are dichotomous
C	=	set of indices of characteristics which are continuously variable
$r(x,\theta)$	=	land rent function defined below
ψ, λ, ξ		are the standard parameters of the Box-Cox functional form.

Since land rents are critical in what follows, the land rent function warrants particular comment. Because much of the data used in hedonic analyses lacks land and location information, the form of the 'land value' component of a hedonic function has not received much attention. Perhaps the most obvious exception to this observation is Jackson, Johnson, and Kaserman (1984) who use a third degree polynomial in two dimensions to model land prices. To economize on the number of required parameters, we use the following land rent function:

$$r(x,\theta) = \beta_1 \cdot e^{x \cdot (\beta_2 + \beta_3 \cdot \sin(n \cdot \theta - \beta_4))} \tag{3.2}$$

where:

x	=	distance from town centre,
θ	=	angle of deflection from East,
β_i	=	parameters to be estimated, and
n	=	an integer which determines the number of radial asymmetries

This rent function possesses the advantage of considerable flexibility while requiring estimation of relatively few parameters[4]. The function allows estimation of asymmetries in land values which may be due to transport networks or topography. The form does not require that land values decrease from the urban center. It is 'monocentric' only in the sense that along any linear path from the city centre land rents will increase or decrease at a constant rate.

Estimates of the parameters of the hedonic price function specified in equations 3.1 and 3.2 are given in Appendix table B.1. From these functions we obtain estimates of the hedonic price of structure and neighborhood characteristics as well as land. Note that neighbourhood characteristics, as discussed in more detail in section 5 below, are formulated to reflect the main amenity outputs produced by the planning system.

The estimated structure price from the hedonic equation, $\widehat{P}$, is a function of the vector of observed characteristics and location. The hedonic price of a continuously variable characteristic q_i is obtained by simple differentiation:

$$p_i = \frac{\partial \widehat{P}}{\partial q_i} = \widehat{\beta}_i \frac{q_i^{\lambda-1}}{\widehat{P}^{\psi-1}} \tag{3.3}$$

Similarly, for a dichotomous variable, the hedonic price is:

$$p_i = \frac{\partial \widehat{P}}{\partial q_i} = \frac{\widehat{\beta}_i}{\widehat{P}^{\psi-1}} \tag{3.4}$$

Finally, letting $\widehat{R}$ represent the estimated price of land (again a function of other characteristics and location), we obtain:

$$\widehat{R} = \frac{\partial \widehat{P}}{\partial L} = r(x,\theta) \cdot \frac{L^{\xi-1}}{\widehat{P}^{\psi-1}} \tag{3.5}$$

These prices are then combined with observed household incomes available, for a subset of the sample, to estimate the structure of demand.

3.2. Almost Ideal Demand System

The Almost Ideal Demand System developed by Deaton and Muellbauer (1980) is well suited for our purposes for two reasons. First, it provides a flexible and theoretically well-grounded framework within which to analyze individual demand data. Second, because it is derived explicitly from a particular expenditure function whose parameters are estimated (or approximated) as part of the estimation of the demand system, it provides for simple implementation of welfare analysis. Once the demand system is estimated, we will also have an expenditure function which can be used to determine the equivalent variation in income associated with changes in land prices.

Making use of the linear approximation of the budget share equations suggested by Deaton and Muellbauer and widely used, we can adapt their model to the present circumstances and obtain a budget share equation of the form:[5]:

$$w_i = (\alpha_i - \delta_i\alpha_0) + \sum_{j\in C} \gamma_{i,j} \cdot \ln p_j + \sum_{k\in D} \gamma_{i,k} \cdot \ln p_k + \delta_i \cdot \ln\left(\frac{M}{I^*}\right) \tag{3.6}$$

where:

w_i	=	expenditure share on characteristic i,
p_j, p_k	=	prices of characteristics,
D	=	set of indices of dichotomous characteristics,
C	=	set of indices of continuous characteristics,
M	=	income,
I^*	=	Stone's price index, defined by $\ln I^* = \sum_i w_i \ln p_i$
$\alpha_i, \alpha_0, \delta_i, \gamma_{i,j}, \gamma_{i,k}$	=	parameters to be estimated.

Then using the hedonic prices given in equations 3.3 and 3.4 above, equation 3.6 can be adapted to:

$$w_i = \overline{\alpha}_i + \overline{\gamma}_i \cdot \ln \widehat{P} + \delta_i \cdot \ln\left(\frac{M}{I^*}\right) + \sum_{j\in C} \gamma_{i,j} \cdot \ln p_j \tag{3.7}$$

where:

$$\widehat{P} = \text{structure value predicted from the hedonic price function,}$$

$$\overline{\alpha}_i = (\alpha_i - \delta_i\alpha_0) + \sum_{k\in D} \gamma_{i,k} \cdot \ln \widehat{\beta}_k$$

$$\overline{\gamma}_i = (1 - \widehat{\psi}) \cdot \sum_{k\in D} \gamma_{i,k}$$

$\widehat{\beta}_k, \widehat{\psi}$ are estimated parameters from the hedonic price function.

3.3. Estimated Demand System

The estimated parameters for the demand system identified in equation 3.7 are presented in the appendix tables C.1, C.2, C.3 and C.4. Estimation of housing and neighbourhood characteristics demand using hedonic prices intrinsically involves the problem of correlation between ‘independent variables’ (the hedonic prices) and disturbances (fluctuations in the quantities of characteristics). This problem has been thoroughly explained in Murray (1983), Bartik (1987) and Epple (1987). As discussed in Cheshire and Sheppard (1995a), the demand system estimates used for this study have been obtained using an instrumental variables approach to address issues of independent variable endogeneity.

The tables present estimated budget share equations only for those characteristics which are not dichotomous. As indicated in equation 3.7 the prices of dichotomous variables are not used in the demand system, since they are constant across the sample. It is possible to estimate budget share equations for the dichotomous variables using the same functional structure as used for the ‘continuous’ variables. These were obtained so that the estimated parameters could be used in the expenditure function for evaluation of the welfare effects of land use controls.

Overall, the estimated budget share equations perform well. While some individual parameters are estimated with high standard errors (and are not statistically significant) this is at least in part due to colinearity between characteristics prices. Furthermore, it is to be expected that not all prices will affect demand for a particular characteristic in a significant way.

4. Equilibrium Utilities and Planning Restrictiveness

The demand system presented in the preceding section includes three neighbourhood characteristics which are intimately connected with operation of land use regulations: the availability of open space which is generally accessible to the public (either through public ownership or extensive public rights-of-way), the availability of open space which is inaccessible, but nevertheless valuable for visual amenity and is used as an instrument to contain the spread of the built-up area, and the limitation of the extent of industrial land use and its separation from industrial areas. Our analysis below will focus on the value of these benefits produced by planning policies, and the costs associated with land use restrictions imposed to produce these amenities, particularly the open space amenities.

The first step in this analysis is to parametrize and determine a utility level for households in the existing equilibrium, and determine the prices which would be faced by households under alternative policy scenarios. Following this we can use a model of land market equilibrium to characterize the extent of planning restrictiveness in each community.

4.1. Utility level

The expenditure function associated with the demand system used above is given by[6]

$$\ln c(u,p) = I^* + u \cdot \prod p_i^{\delta_i} \tag{4.1}$$

Households have a given after tax income M, and spend part of this income on transport costs $t(x,\theta)$, leaving $M - t(x,\theta)$ available for expenditures on goods and services from which utility is derived. This implies an indirect utility function for each household having the form[7]:

$$\widehat{u} = \frac{\ln(M - t(x,\theta)) - I^*}{\prod p_i^{\delta_i}} \tag{4.2}$$

To utilize this for estimating utility levels, we must determine the transport costs faced by a household located at location (x,θ). The first thing to note is that estimates of the land values obtained from the hedonic function discussed above and shown in appendix table B.1 indicated considerable radial asymmetries. These are to be expected given the fact that roadways and other components of transport infrastructure are not radially symmetric, and it was shown in Cheshire and Sheppard (1995b) that these asymmetries faithfully reflect those of the transport system. In determining the transport cost function, we expect that the function t would exhibit asymmetries and a directional orientation that would be associated with the land value surface which has been estimated from the data.

We take transport costs per mile per annum to be:

$$t(x,\theta) = \tau x\,(1 + \nu \sin(n\theta - \beta_4 - \pi)) \tag{4.3}$$

$$\text{where } \begin{cases} n = 2 & \tau = 403.49 & \upsilon = 0.46156 & \text{for Reading} \\ n = 1 & \tau = 288.4983 & \upsilon = 0.28451 & \text{for Darlington} \end{cases}$$

and the parameter β_4 is taken from the estimated hedonic price function for each city, as reported in table B.1. The parameter values shown capture (via parameters n and ν and β_4) the asymmetries observed in the estimated land values, and are based upon estimated vehicle running costs[8] and the value of time (as estimated by the sample mean income levels and mean travel speeds).

Beyond structural asymmetries, the overall level of transport costs is determined by two factors: actual operating costs (or fares if using public transport) and the time costs of travel. The parameter τ determines the overall level of transport costs, and is chosen so that the average transport cost per mile equals the amount expected from available estimates of vehicle running costs plus time costs.[9]

Given these transport costs we calculate, for each household, a vector of utility levels[10] $\mathbf{u}_1$ with each component determined by equation 4.2. For Reading, this calculation indicates a mean utility level of 21.585 and for Darlington, the mean utility level is estimated to be 19.797.

4.2. Levels of planning restriction

The expenditure function given in equation 4.1 can also be used to derive the general form of the equilibrium land value. An optimising consumer makes a choice which satisfies:

$$\ln\left(M - t(x,\theta)\right) = I^* + u \cdot \prod p_i^{\delta_i} \tag{4.4}$$

Assuming without loss of generality that land area is indexed as good 1, we have:

$$r(u,x,\theta,p,M) = \left(\frac{\ln\left(M - t(x,\theta)\right) - I^*}{u \cdot \prod\limits_{i \geq 2} p_i^{\delta_i}} \right)^{\frac{1}{\delta_1}} \tag{4.5}$$

Given estimated parameters for the demand system, and a utility level, we can use this to calculate bid-rents for a typical household at any location.

It is then possible to make use of this land value within the context of a standard monocentric urban model. Let $h(u,r,p)$ be the compensated demand for land for a consumer whose preferences generate an expenditure function of the form 4.1, where r is land rent and p is the vector of all prices. If the city were occupied by a single class of identical individuals, then equilibrium in the land market would require:

$$N = \int_{\chi_1}^{\chi_2} \int_0^{2\pi} \frac{\omega \cdot x}{h(u, r(u,x,\theta,p,M), p)} \, d\theta \, dx \tag{4.6}$$

where:

- N is the total number of households to be accomodated within the urban area
- ω is the share of space internal to the urban area made available for residential use;
- χ_1 is the inner boundary of allowed residential development;
- χ_2 is the outer boundary of residential development, and of the urban area.

The parameters ω, χ_1, and χ_2 are determined by planning policy, and are of central interest in the evaluations below. The parameters χ_1 and χ_2 are estimated from the observed structure of each urban area. Given these estimates for the residential boundaries, we estimate the parameter ω by adapting equation 4.6 to obtain:

$$\hat{\omega} = \frac{N}{\int_{\chi_1}^{\chi_2} \int_0^{2\pi} \frac{x}{h(\bar{\mathbf{u}}, r(\bar{\mathbf{u}},x,\theta,\bar{\mathbf{p}},\overline{\mathbf{M}}), \bar{\mathbf{p}})} \, d\theta \, dx} \tag{4.7}$$

and evaluating at sample mean levels of utility, income, and non-land prices: $\bar{\mathbf{u}}$, $\overline{\mathbf{M}}$, and $\bar{\mathbf{p}}$. That is, we estimate the implicit level of planning restrictiveness by solving for the equilibrium of a land market

City	$\widehat{\omega}$	$\bar{\mathbf{u}}$	N	χ_1	χ_2
Reading	.384125	21.585	80000	1525.927	23047
Darlington	.427157	19.797	36000	1562.839	11979

Table 4.1: Estimated utility and level of planning restriction

accommodating N households who have identical incomes, face identical non-land prices, and achieve identical utility levels - with each of these determined by the sample mean.

The parameter ω represents the share of land area made available for residential development between the inner and outer boundaries χ_1 and χ_2. This parameter will always be less than one, since some land is used for transport infrastructure and other land uses. Local land use policy concerning the provision of internal open space - whether accessible in the form of parkland or inaccessible, 'visual amenity' open space like pasture and other agricultural use - will be the major determinant of differences in ω between topographically similar cities.

Table 4.1 presents the estimates of $\hat{\omega}$ along with the parameters $\bar{\mathbf{u}}$ (the mean utility levels), N (the number of households), χ_1 and χ_2 (inner and outer limits of the built-up area, in feet). The number of households is estimated from Census small area statistics for the built-up area, the inner limit χ_1 is estimated from the sample as the minimum observed distance from the urban centre, and the outer limit χ_2 is estimated from Ordnance Survey maps showing the extent of each city.

Note that as expected, Reading makes less land available for private residential use than Darlington. Note that the estimated levels of $\hat{\omega}$ are based on the estimated demand system in each city, and thus correct for most of the other differences between these two areas (such as income levels or the prices and availability of other amenities and structure characteristics). These utility levels and measures of planning policy are taken as the basis from which changes in planning policy will be evaluated.

5. Benefits of Planning Amenities

We focus on the community with the more restrictive planning regime, utilising the demand system to provide some estimates of the gross value of benefits from these amenities, and the distribution of these benefits amongst households.

5.1. Estimation of benefits

To obtain an estimate of the 'gross benefits' of planning amenities, we assume that effectively none of the amenity would be produced in the absence of planning. This is most reasonable in the case of inaccessible open space, and is probably less acceptable in the case of absence of industrial uses in conjunction with residential use. For each household, we can then calculate the variation in income which would be sufficient to achieve the current utility level if it faced the amenity price associated with the absence of land use planning. In this way an estimate of the benefit received by each household is calculated. We analyze

Amenity	**Mean £**	σ	min	max	$\mathbf{r}_Y$	$\mathbf{r}_{area}$	$\mathbf{r}_{value}$	**gini**	$\mathbf{gini}_Y$
Accessible Space	3606.66	1505.37	1169.8	10838.5	.696	.786	.848	22.51	20.75
Inaccessible Space	1275.23	1120.82	233.43	6909.99	.450	.451	.559	44.32	21.54
Industrial Land	1919.32	691.78	0	3495.95	.674	.486	.524	20.03	19.78

Table 5.1: Value of Benefits from Planning Amenities

both the distribution of this benefit alone, and since we have observed household income the effect on the distribution of income as augmented by the value of these benefits.

For the two types of open space, we assume that essentially zero would be produced in the absence of the planning system and that land would instead be allocated to various types of private consumption. Using the demand system evaluated for a 'typical' household (that is a household with income equal to the sample mean facing sample mean prices for other characteristics), we make a separate determination of the price at which demand for each amenity would be reduced to zero. For open space amenities, we used the following procedure: let p_1 denote the vector of prices in which all characteristics take prices as estimated via equations 3.3, 3.4, and 3.5. Let p_2 denote the vector of prices in which all prices remain the same except the price of the given open space amenity is increased to this 'reservation price'. Then for each household, we estimate the gross benefit from the given amenity by:

$$c(u_1, p_2) - c(u_1, p_1) \tag{5.1}$$

where the utility level u_1 is obtained for each household via equation 4.2. This provides the increase in income required to achieve the current level of welfare if the price of the amenity were increased to its reservation price.

For limitation of industrial land use, the 'reservation price' was taken to be the highest price for limiting industrial land use observed in the sample. This is seen to provide a more reasonable measure of the benefits from limiting industrial land use once we recall the interpretation of each variable. When the measure of open space amenity reaches zero, the interpretation is zero open space and more land available for private residential or commercial uses, and we expect this outcome in the absence of any planning or zoning constraints. When the industrial land use variable reaches zero, the interpretation is that 100 percent of the land in the surrounding square kilometer is in industrial use. This extreme scenario would not describe the absence of a planning system. As a reasonable alternative datum, we therefore assume a scenario in which all households face the same exposure to industrial land use as the most exposed property in the sample.

Table 5.1 presents the results for each planning amenity. The second column of the table lists the mean value of estimated gross benefits[11] for each amenity, followed by the standard deviation, minimum and maximum values, correlation with household income, correlation with plot size, and correlation with the price of the house.

5.2. Distributional consequences

We focus on two separate issues regarding the distributional consequences of land use planning. The first concerns the equity, or lack thereof, with which the benefits (and later the net costs) are distributed. The second concerns the distribution of 'effective' income after consideration of the benefits or costs. The issues deserve separate consideration and each seems of interest. The value of planning benefits might be quite equally distributed but, depending on the correlation between household income and benefit received, might increase or decrease the overall level of inequality within the society.

The assessment made concerns the distribution of benefits within our sample. Since it is drawn exclusively from the population home owners, the level of inequality is much less than that observed in the entire UK population. The gini coefficient for after tax income in the Reading sample is 20.52. For this time period the index for after tax income for the entire UK was approximately 38.1. For more details, see Central Statistical Office (1985) and Central Statistical Office (1986).

The last two columns of table 5.1 provide information on how these benefits are distributed. The penultimate column presents the calculated gini coefficient for distribution of the gross benefit alone, and the last column gives the gini index of household income augmented by the value of the benefit. Thus provision of open space generates a slight increase in inequality in society, while limitations on industrial land use might be said to generally reduce inequality.

Figure 5.1 shows Lorenz curves for the distribution of gross benefits from each of the three amenities. This makes the differences in distributional equity quite clear. It is not surprising that the benefits from inaccessible open space are much less equally shared among households than benefits from the other amenities, since most of this type of open space is available at the urban fringe as part of the 'greenbelt' which contains the urban area.

An interesting comparison can be made with the distributional consequences of 'in kind benefits' in Britain, made available in the annual reports from the treasury. The analysis covers a variety of benefits, including state education, school meals and other meal subsidies, the national health service, rail, bus, and other travel subsidies. Collectively, these lower the gini coefficient of income after direct and indirect taxes by about 10.11 percent. Our calculations suggest that the combined consequences of planning amenities is almost distributionally neutral, with a 3.6 percent decline in the gini resulting from limiting industrial land use generally offsetting the 4.97 percent increase resulting from inaccessible open space, and the 1.12 percent increase from accessible open space. Although these combine to yield little change in the aggregate distribution of welfare, individually they are quite significant, and likely to be as large as many of the public services traditionally structured with at least a partly egalitarian objective.

Figure 5.2 shows the distribution of gross benefit levels from accessible open space, and figure 5.3 shows how these benefits are distributed between income quintiles (with quintiles defined on income after taxes but exclusive of any imputed planning benefit). The numeric labels at the top of each bar show the actual percentage of total benefits realized by each quintile, and the line superimposed over the bars shows the actual distribution of income going to each quintile.

Thus for accessible open space, we see that the change in effective income distribution mostly arises by

Figure 5.1: Distribution of benefits from three planning amenities

Figure 5.2: Distribution of benefits from accessible open space

Figure 5.3: Share of gross benefit from accessible open space to each income quintile

the poorest quintile getting a share of benefits larger than their corresponding income share, and 'paying' for this primarily by the fourth quintile getting less than their income share.

Figures 5.4 and 5.5 present the same information for inaccessible open space. The less equal distribution of these benefits, and their more regressive final impact, is immediately apparent. Figure 5.5 clearly shows the regressive nature of the benefit with the benefit shares rising more rapidly than income shares.

Finally, the distribution of benefits from limiting industrial land use below the most industrialized area found in Reading is shown in figures 5.6 and 5.7. Note that while the benefits of limiting industrial land use are, by themselves, distributed regressively with disproportionate amounts going to upper income persons, nevertheless this amenity contributes to a reduction in inequality because it is less unequally distributed than after tax income. Limitation of industrial land use is seen to be the most redistributive of the benefits, with the first and second quintiles getting clearly a larger share of benefits than their income shares, with the fourth and fifth getting clearly less.

The gross benefit estimates for the three planning amenities are quite large and from a political economic perspective help to explain the widespread appeal and general support given to implementation of land use planning restrictions. These activities produce amenities which are highly valued by a large number of residents. A further point is that households are financially locked into the system. Since planning amenities are capitalised into the price of the aggregate 'house-land bundle', a reduction in amenities by, say, permitting development on inaccessible open land would produce a capital loss for existing house owners (although, as we see below, it would be consistent with increasing overall community welfare).

The estimates show that planning benefits are certainly not distributed equally. Furthermore, the ben-

Figure 5.4: Distribution of benefits from inaccessible open space

Figure 5.5: Share of gross benefits from inaccessible open space to each income quintile

Figure 5.6: Distribution of benefits from limiting industrial land use

Figure 5.7: Share of benefit to income quintiles from limiting industrial land use

efits arising from all three types of amenities flow disproportionately to upper income groups, although only inaccessible open space produces benefits which are more unequally distributed than income itself. Our findings seem to suggest that the greatest inequities are not in those benefits traditionally associated with high exposure to pollutants (industrial land use) but rather in the provision of 'green' amenities like open space.

We next turn attention to the net welfare costs of planning in efficiency terms. We do this by using the estimated parameter values to simulate the effects of alternative planning regimes.

6. Net Costs of Land Use Planning

To acknowledge that the amenities produced by the planning system are valuable to some, even all, persons in the community is not to establish that the quantity provided is efficient. The marginal units of amenities provided may still fail a benefit-cost test. Application of such a test, as noted above, is made more difficult by the fact that the amenities are provided through regulation rather than through a market transaction. The latter would involve explicit taxation of some sort and collective purchase of the inputs required to produce the public good. We could then compare the costs with estimates of the benefits. With land use planning the costs come in the form of distortions in land and housing prices, and we must attempt to estimate the price distortions that result from the policy, and compare the value of this change with the value of the change in amenity provided.

A fundamental difficulty which confronts this approach is to determine what changes in land prices might actually be attributable to the policy. The very pervasiveness of land use planning makes observing an economy with no land use regulation very difficult. We adopt an approach which will provide, we argue, a lower bound estimate of the net costs of land use planning in a highly constrained community: it is thus a lower bound estimate of the maximum cost in the economy under investigation – Britain. At a minimum our approach can be said to provide an evaluation of the potential costs and benefits of reforming an existing land use planning system.

We have identified two comparable urban areas which, though subject to the same land use regulation system, operate these regulatory constraints very differently. Through careful analysis of what appears to be one of the least restrictive planning regimes, and comparison with what appears to be one of the most restrictive, we can provide an evaluation of the changes in land prices which may be attributed to the more restrictive planning regime. Combining this with an evaluation of the reduction in the level of benefits from open space will provide a measure of the net costs of land use planning.

6.1. Provision of open space within urbanized area

In table 4.1 above we presented results of estimates of the parameter ω which represents the extent to which land is made available for private residential consumption in each city. The data presented in table 2.1 suggests that the two cities represent extreme implementations of the Town and Country Planning system, with Reading being the most restrictive and Darlington the least. We attribute the differences in estimated levels of ω to the difference in land use planning regimes in the two cities.

The impact of two possible policy changes is evaluated. In this section we provide estimates of the impact which would result if the more constrained community – Reading – adopted the more relaxed regime of internal open space availability observed in Darlington. In the next section the effects of relaxing the constraint on building beyond the present boundary of the built-up area are estimated.

The first policy change – Reading adopting Darlington's 'permissive' regime on internal space availability – itself would generate at least two major changes: first there will be an increase in availability of residential land – an increase in ω from $\omega_1 = 0.384$ to $\omega_2 = 0.427$. Equilibrium in the urban land market will then require a reduction in land rents, with an associated increase in household utility levels. Associated with such a policy shift would be a reduction in internal open space available to the community. We assume that the reduction in open space is taken from both accessible and inaccessible open space so that the ratio of the two types of open space provided remains constant. The change in consumption of private residential land resulting from implementation of ω_2 in place of ω_1 amounts (over the allowed range of residential construction) to approximately 71.5 million square feet of land[12]. To release this much land to private consumption would require an 11.45 percent reduction in the amount of available open space in the urban area.

Using elasticities estimated from the demand system, we estimate that such a reduction in open space would increase the price of accessible open space by 10.2 percent, and the price of inaccessible open space would increase by 10.1 percent. Let the price vector $\mathbf{p}_2$ represent, for each household, the prices of housing and neighbourhood characteristics with the price of open space increased by these amounts. Let $\overline{\mathbf{p}}_2$ be the vector of mean prices for the sample, reflecting the increased price for open space. The associated price vectors before any change (representing the *status quo*) are $\mathbf{p}_1$ and $\overline{\mathbf{p}}_1$.

If the level of planning restrictiveness were reduced, and the price of internal open space were increased to release the associated amount of land for private consumption, a new equilibrium would be reached with utility level u_2. This utility level can be determined by solving:

$$N = \int_{\chi_1}^{\chi_2} \int_{0}^{2\pi} \frac{\omega_2 \cdot x}{h(u_2, r(u_2, x, \theta, \overline{\mathbf{p}}_2, \overline{\mathbf{M}}), \overline{\mathbf{p}}_2)} \, d\theta \, dx \tag{6.1}$$

for utility level u_2. This utility level would be achieved, *on average*, for households in the sample. The utility level can be used to provide an estimate of the new level of land rent at each location $r(u_2, x, \theta, \overline{\mathbf{p}}_2, \overline{\mathbf{M}})$, so that for each actual household in the sample, we have an estimate of the change in the price of land as well as the change in the price of open space.

For each household, actual income would remain unchanged. Implicit differentiation of the expenditure function allows us to determine the marginal indirect utility of a change in price:

$$\frac{\partial u}{\partial p_i} = -\frac{\frac{\partial c(u,r,p)}{\partial p_i}}{\frac{\partial c(u,r,p)}{\partial u}} = -\frac{h_i(u,r,p)}{\lambda} \tag{6.2}$$

Thus the marginal indirect utility of a change in price is proportional to consumption of the good, with the factor of proportionality $-\frac{1}{\lambda}$ equal to minus the reciprocal of the 'marginal cost of utility'. This observation suggests the following approach for estimating the change in utility for each individual household. Determine a vector of utilities $\mathbf{u}_2$ by solving for φ to satisfy:

$$\begin{aligned} \mathbf{u}_2 &= \mathbf{u}_1 + \varphi\left(\mathbf{L}\blacksquare\mathbf{r} + \mathbf{q}_a\blacksquare\mathbf{p}_a + \mathbf{q}_i\blacksquare\mathbf{p}_i\right) \\ \bar{\mathbf{u}}_2 &= u_2 \end{aligned} \tag{6.3}$$

where:

$\bar{\mathbf{u}}_2$	=	mean of vector $\mathbf{u}_2$
$\mathbf{L}$	=	quantity of land consumed by an individual household
$\blacksquare\mathbf{r}$	=	change in land rent at the household's location
$\mathbf{q}_a$	=	quantity of accessible open space consumed by the household
$\blacksquare\mathbf{p}_a$	=	change in price of accessible open space at the household's location
$\mathbf{q}_i$	=	quantity of inaccessible open space consumed by the household
$\blacksquare\mathbf{p}_i$	=	change in price of inaccessible open space at the household's location
φ	=	factor of proportionality to determine change in utility level

Using equation 6.3 we solve for the factor of proportionality φ, and obtain an estimated vector of new utilities for each household $\mathbf{u}_2$. We use this to calculate a vector of net costs of planning for the sample[13]:

$$c\left(\mathbf{u}_2, r\left(u_1, \mathbf{x}, \theta, \bar{\mathbf{p}}_1, \overline{\mathbf{M}}\right), \mathbf{p}_1\right) - c\left(\mathbf{u}_2, r\left(u_2, \mathbf{x}, \theta, \bar{\mathbf{p}}_2, \overline{\mathbf{M}}\right), \mathbf{p}_2\right) \tag{6.4}$$

In equation 6.4 we generate a vector of rents by evaluating $r(\cdot)$ at every location given by the vectors $\mathbf{x}$ and θ. We then have a vectors of utilities $\mathbf{u}_2$ and rents, and a matrix of prices $\mathbf{p}_i$ with one row for each observation.

Evaluating the expenditure function at each row then gives income net of transport costs required to achieve the utility level associated with the permissive planning regime under the two alternative sets of land and amenity prices. The difference gives the equivalent variation associated with the change in planning policy. A positive number indicates that greater expenditures would be required under the observed restrictive planning policies to achieve utility level $\mathbf{u}_2$. Table 6.1 provides a summary of these calculations.

Provision of open space within urban area								
μ	σ	min	max	$\mathbf{r}_{\text{income}}$	$\mathbf{r}_{\text{area}}$	$\mathbf{r}_{\text{value}}$	**gini**	$\mathbf{gini}_{\text{Y}}$
159.69	84.14	48.86	698.62	.649	.858	.832	26.30	20.55

Table 6.1: Net Costs of Internal Land Availability Policies

As indicated, all households in the sample appear to experience positive net costs from the current land use planning policy. On average, a relaxation of the policy would be equivalent to an increase in income of nearly £160 per annum. There is considerable variation in the levels of net costs experienced by different households. Figure 6.1 shows the distribution of costs, giving the proportion of households who

Figure 6.1: Net costs of constraints on supply of residential land

experience costs at various levels. The fifth, sixth, and seventh columns of table 6.1 show the correlation between net cost of providing such a large supply of internal open space and household income, land consumption, and house value respectively. The correlation with income is positive but, unsurprisingly, not as strong as is that with land consumption.

Figure 6.2 shows the distribution of net costs by income quintiles, along with income shares received by each quintile. In contrast to the discussion of gross benefits presented above, we are here looking at costs net of benefits. If upper income groups experiences greater cost shares than their income share, then the policy may be viewed as generally redistributive.

The penultimate column of table 6.1 presents a gini coefficient for the distribution of costs, indicating the inequality with which the costs themselves are shared over observations in our sample. The final column presents what might be called an 'income equivalent' gini coefficient for income. That is, we take household income and add the income which would be equivalent to adopting the less restrictive land use planning regime. Both figure 6.2 and the 'equivalent income gini' show internal open space policies to be generally neutral. The middle quintile comes out about even. The second and third quintiles gain somewhat at the expense of the richest and poorest quintile. Without affecting the overall gini much, internal open space policies appear relatively to benefit the middle class at the expense of the rich *and* the poor. This is an observation about relative position only. All income groups experience positive net costs and, the evidence suggests, would benefit from adoption of the more permissive planning regime.

While the net costs of providing a higher level of internal open space are not small over the entire urban area, amounting to about £12.775 million per annum, they are moderate for individual households. By way of comparison, the mean level of net costs are about 53.5 percent of the then current level of local

Figure 6.2: Net cost shares to income quintiles from internal open space constraint

rates,[14] so the net costs are significant relative to the level of tax paid to local government. We next turn attention to the net cost associated with a more comprehensive view of what constitutes land use planning.

6.2. Containment of urbanized area

In the preceding section, we provided estimates of the net costs associated with policies designed to provide open space within the residential area of the city. Next we consider not only this ‘interior open space’ component of planning, but also the ‘containment’ policies whereby planners seek to contain the urban area within the existing boundaries of the built-up area (or ‘settlement envelopes’) preventing urbanisation spreading to existing agricultural land. So called ‘greenbelts’ represent the best known but most expensive instrument of this policy. The approach is generally similar to that used previously. We consider replacing the *status quo* planning regime with one in which the internal open space parameter ω is raised from $\omega_1 = 0.384$ to $\omega_2 = 0.427$, *and* the maximum extent of residential development is not constrained at χ_2 but is allowed to expand until the price of developed residential land is equal to the price of vacant agricultural land plus some essential premium required to bring such land into urban use.

As in the previous case, we must determine the change in land rents and the change in the effective price of open space. This latter price will naturally increase for two reasons: first is the reduction in internal open space which is associated with the increase in ω. Second, the increase in the spatial extent of residential development implies that fewer households will live within a kilometer of the settlement envelope, and will therefore experience reduced access to open space. The first factor, with its associated

11.45 percent decrease in open space, is handled as in the previous section.

To capture the effect of the second factor, we further reduce all open space consumption by a factor which reflects the difference between open space consumption of those households in the sample which live within one kilometer of the urban periphery and those living closer to the centre. This results in a further 1.17 percent reduction in accessible open space, and a 13.74 percent reduction in inaccessible open space. The larger reduction in inaccessible open space is to be expected, since much of the open land beyond the urban periphery is not open to the general public. Let the matrix $\mathbf{p}_3$ provide a price vector for each household which reflects these higher prices for open space, and $\overline{\mathbf{p}}_3$ represent the associated vector of sample mean prices.

If we are to replace χ_2 with the distance $\widetilde{x}$ at which residential land values equal the price of vacant land, we must determine a price for vacant land. The appropriate price for vacant land should be several times the price of agricultural land for several reasons. First, land that is cleared and prepared for development has some investment applied which already raises its value above vacant land in agricultural use. Second, as discussed in Titman (1985), Capozza and Helsley (1990), and Capozza and Sick (1994) *inter alia*, the price at which land will be held vacant depends in part on the stochastic structure of the price of residential property. As noted in Mayo and Sheppard (1991), the vacant land price can therefore depend upon the nature of 'development controls' and land use planning.

The estimates presented below are based on a vacant land purchase price of £20000 per acre. This level represents a multiple of agricultural land values which is similar to that observed in North American cities[15]. It also results in eventual population densities which are similar to those observed in North American cities[16] of the size being considered here.

For a mean utility level experienced within the urban area of u_3, the maximum extent of residential development will be

$$\widetilde{x} = r^{-1}\left(u_3, 20000, \theta, \overline{\mathbf{p}}_3, \overline{\mathbf{M}}\right) = \left\{x \,\middle|\, r\left(u_3, x, \theta, \overline{\mathbf{p}}_3, \overline{\mathbf{M}}\right) = 20000\right\} \tag{6.5}$$

The utility level which equilibrates the urban land market in this case can be determined by solving for u_3 in the equation:

$$N = \int_{\chi_1}^{r^{-1}\left(u_3, 20000, \theta, \overline{\mathbf{p}}_3, \overline{\mathbf{M}}\right)} \int_0^{2\pi} \frac{\omega_2 \cdot x}{h(u_3, r(u_3, x, \theta, \overline{\mathbf{p}}_3, \overline{\mathbf{M}}), \overline{\mathbf{p}}_3)} \, d\theta \, dx \tag{6.6}$$

After solving for the mean utility level u_3, we obtain a vector of estimated utilities $\mathbf{u}_3$ using a procedure similar to that outlined in equation 6.3. We then estimate the net cost of the combined land use planning policies by:

$$c\left(\mathbf{u}_3, r\left(u_1, \mathbf{x}, \theta, \overline{\mathbf{p}}_1, \overline{\mathbf{M}}\right), \mathbf{p}_1\right) - c\left(\mathbf{u}_3, r\left(u_3, \mathbf{x}, \theta, \overline{\mathbf{p}}_3, \overline{\mathbf{M}}\right), \mathbf{p}_3\right) \tag{6.7}$$

Table 6.2 presents a summary of these calculations. The net cost per household is much larger when we consider this more complete picture of what constitutes the restrictiveness of land use planning policies on the supply of urban land. It amounts to nearly 13 percent of household income. It must be stressed that these are net costs, taking into account the reduction in open space which households experience. While

Provision of internal open space and containment								
μ	σ	min	max	$\mathbf{r}_{\text{income}}$	$\mathbf{r}_{\text{area}}$	$\mathbf{r}_{\text{value}}$	**gini**	$\mathbf{gini}_{\text{Y}}$
1356.63	1301.91	349.69	13688.10	.409	.918	.700	34.01	21.39

Table 6.2: Net Costs of Open Space and Containment Policies

Figure 6.3: Net cost of ‘containment’ and ‘internal open space’ constraints

this amenity is valuable to households, the decrease in land (and hence housing) costs overwhelms the increase in effective price of open space.

As before, note that the correlation between net costs and income is weaker than the correlation between land consumption or overall house value. The gini index for distribution of the net costs of land use planning indicates considerable inequality between households in bearing these costs. This is further illustrated in figure 6.3, which shows a highly skewed distribution of net costs.

Figure 6.4 shows the distribution of net costs between income quintiles. Upper income households bear a disproportionate share of the costs of planning, with middle class quintiles 2 and 4 again being relatively favored. As in the preceding sections, all income groups experience net costs and would appear to benefit from a regime of land use regulation that while producing fewer amenity benefits was less restrictive on urban land supply.

This is further substantiated by examination of the ‘income equivalent’ distribution obtained by adding observed household income to the income equivalent associated with adoption of an unconstrained land use planning policy. The resulting gini coefficient of 21.39 represents a 4.2 percent increase in income inequality compared with the distribution of income observed in our sample. In this sense, land use planning is generally redistributive, comparing (as noted above) with a variety of other ‘in kind’ benefits

Figure 6.4: Net cost shares to income quintiles from internal open space and containment

distributed to consumers. This increase in overall equality is, however, purchased at a considerable price - with total net costs amounting to nearly £109 million pounds per annum for the Reading urban area, or nearly three times the amount of local rates. Another way of expressing it is as a tax on household incomes of around 10%.

The net costs of this more comprehensive view of land use planning are also considerably less equally borne by residents than the costs of internal open space provision alone. This is illustrated graphically in figure 6.5, which shows Lorenz curves for the distribution of the net costs of planning constraints, independent of household income. The observed differences reflect the increase in the gini associated with the distribution of these costs from 26.30 for the internal open space provision to 34.01 for open space provision plus containment.

7. Concluding remarks

How does this methodology compare with others that might be available? Horowitz (1984), for example, presents a method for calculating equivalent variations in income directly from estimated hedonic price functions. One difference which characterizes the approach of this paper is the use of equilibrium in the urban land market. Since changes in planning regimes are ‘system wide’ phenomena, they will certainly result in significant changes in the overall structure of land market equilibrium in the city, changes which are not observed in the estimation of a hedonic price function. While Horowitz’s approach may be useful

Figure 6.5: Distribution of costs from plannng policies

for measurement of the gross benefits from planning amenities, evaluation of the costs requires estimation and evaluation of the new equilibrium.

We have presented an approach for evaluation of some of the economic consequences of land use planning. In particular, we have considered the income-equivalent costs of land use restrictions with their consequent associated increase in land and housing prices. By focusing on two urban areas with contrasting planning regimes, we obtain estimates of these effects as a test of our methodology.

We find the net costs to be significant, as much as 13 percent of annual household income. We find perverse distributional consequences for some parts of the land use planning system. Distribution of benefits from planning amenities tends to favor upper income groups. This is particularly true of the benefits associated with containment. Interestingly, given expressed public and 'official' concern about the impact of environmental policies on low income neighbourhoods, we find benefits from limiting industrial land use to be the most equitably distributed of all land use planning amenities.

A variety of extensions to the research might be pursued. It would be useful to verify that there are not other benefits produced by land use planning which have not been measured in this study and which might alter the estimated net costs. It would be of further interest to embed the analysis within a more comprehensive general equilibrium model, as done by Hazilla and Kopp (1990) which may identify additional economic costs of planning[17] which need to be considered. The analysis presented here concentrates on the costs that arise through operation of the market for residential land which comes as part of owner-occupied properties. Land use regulation obviously affects several other sectors of the economy.

In any event, the methods we develop are computationally feasible and could be widely applied. They do, however, require data which provide information on residential structure values and characteristics, including land and location as well as the incomes of the households occupying the sample houses. Given such data, the analysis could be of benefit to planners and policy makers. The results also reinforce the often repeated advice of economists that the provision of public goods by regulation has the additional disadvantage from a liberal viewpoint: the real costs are not directly visible, but require some effort and ingenuity even to approximate. That they are not visible, however, does not mean that they are not real nor, in the case at least of British land use planning, that they cannot be substantial.

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A. Variables and descriptive statistics

Variable Name	Description
Income after tax	After tax household income obtained from survey in £'s
Price[1]	Rentalised after-tax annual cost of structure in thousands of £'s
Bedrooms[1]	Number of bedrooms in the structure
WC's[1]	Number of WC's in the structure
Terrace[1]	1 if property is Terrace style
Semi[1]	1 if property is Semi-detached
Flat[1]	1 if property is a Flat
Parking[1]	1 if property has off-street parking
Garage[1]	1 if property has a garage
Central Heat[1]	1 if structure has central heating
Floors[1]	Defined as (5 - number of floors in structure)
Plot Width[2]	Width of plot in feet
Sq. Feet[1]	Square feet of living area in structure
Land (L)[2]	Area of land in square feet associated with the structure
Distance[2]	Distance in miles from city centre
Theta[2]	Angle in radians from East
School A[3]	1 if located in 'premium' secondary school A catchment area
School B[3]	1 if located in 'premium' secondary school B catchment area
School C[3] : Reading only	1 if located in 'premium' secondary school C catchment area
Street 1[2]	1 if located on minor road
Street 2[2]	1 if located on road with $>$ 4.3 metres metalling : Datum in Darlington
Street 3[2]	1 if located on a 'B-class' roadway : Datum in Reading
Street 4[2]	1 if located on an 'A-class' roadway
Bus[2,4]	1 if property within 3 mile of local bus route
Blue Collar[5]	(100 - fraction of ward labour force in blue collar occupations)
Ethnic[5] : Reading	(15 - % of urban area's afro-caribbean population located in ward)
Ethnic[5] : Darlington	(20 - % of area's asian population located in ward)
Altitude[2]	Maximum altitude (metres) in 1 km OS square containing address
Industrial Land[2,6]	(100 - Percent of land in Industrial use within 1km OS square)
New Construction[2,6]	{ For Darlington: 1 if majority of observations in 1km OS square are new construction; For Reading, 1 if majority of observations in 1km OS square are NOT new construction
Open Land Amenity[2,6]	Percent of land in accessible open space in 1km OS square
Closed Land Amenity[2,6]	Percent of land in inaccessible open space 1km OS square
Sources:[1]Estate Agents Particulars; [2]Ordnance Survey; [3]Local Education Authority [4]Reading Transport; [5]1981Population Census, Ward Data; [6]Aerial Photographs	

Table A.1: Variable Descriptions

Variable	Reading μ	Reading σ	Darlington μ	Darlington σ
Continuous Characteristics				
Income After Tax	10577.57	3862.51	8869.79	4006.08
Asking Price	51065.99	20767.35	23852.7	13996.06
Rentalized Price	4.468	1.817	2.087	1.225
Bedrooms	3.113	0.949	2.823	0.911
WC's	1.49	0.664	1.122	0.543
Square Feet	832.463	356.581	794.483	333.209
Floors[1]	3.074	0.442	3	0.29
Land Area	4340.436	4546.668	2296.004	1905.702
Plot Width	35.768	27.106	27.398	17.058
Distance to CBD	2.195	1.018	1.01	0.464
Blue Collar[1]	55.078	14.987	39.603	21.82
Ethnic[1]	10.781	3.655	14.12	3.288
Altitude	68.669	16.097		
Amenity Land I (open)	18.169	12.507	8.619	7.806
Amenity Land II (closed)	8.330	16.322	9.643	15.543
Industrial Land	95.522	7.140	90.382	13.984
Dichotomous Characteristics				
Terrace	0.133	0.34	0.434	0.496
Semi	0.345	0.476	0.392	0.489
Flat	0.097	0.296	0.006	0.08
Parking	0.21	0.408	0.228	0.42
Garage	0.641	0.48	0.437	0.497
Central Heat	0.801	0.399	0.54	0.499
School A	0.149	0.356	0.154	0.362
School B	0.093	0.29	0.164	0.371
School C	0.081	0.274	0.238	0.427
School D			0.244	0.43
Street 1[1]	0.291	0.455	0.637	0.482
Street 2[1]	0.12	0.325	0.074	0.262
Street 3[1]	0.016	0.125	0.013	0.113
Street 4[1]	0.059	0.235	0.026	0.159
New Construction	0.820	0.384	0.052	0.221

[1]These variables were defined so that an increase in the variable was expected to be more desirable. See table A.1 above for variable definitions.

Table A.2: Descriptive Statistics for Sample

B. Estimated hedonic price function

Variable	Reading estimate	Reading t	Darlington estimate	Darlington t
Constant	-0.89318	-5.51	-1.79801	-5.78
Continuous Structure Characteristics				
Bedrooms	0.07369	4.08	0.30587	4.50
WC	0.07654	4.50	0.11219	1.78
Floors	0.08409	2.65	0.42815	4.57
Plot Width	0.01943	2.02	0.01297	0.68
Square Feet	0.07409	3.62	0.01010	0.46
Dichotomous Structure Characteristics				
Terrace	0.02788	1.43	0.07337	0.47
Semi	0.03278	1.82	0.28446	1.88
Detached	0.11230	4.84	0.55044	3.57
Parking	0.01982	1.39	0.01855	0.64
Garage	0.05230	3.28	0.07368	2.06
Central Heating	0.04771	4.08	0.11683	4.78
Schools				
School A	0.08368	4.52	0.12076	2.35
School B	0.05902	3.35	0.10965	3.24
School C	0.02440	1.34	not included	
Socio-Economic Characteristics				
Blue Collar	0.01193	0.98	0.06146	1.21
Ethnic	0.02630	2.92	0.04462	1.73
Transport infrastructure				
Street 0	0.05131	1.52	0.05063	1.14
Street 1	0.04797	1.41	0.01463	0.37
Street 2	0.04803	1.39	datum	
Street 3	datum		0.19120	1.87
Street 4	0.07527	1.99	0.05144	0.64
Bus Access	0.00652	0.82	not available	
Planning and topography				
Altitude	0.00843	0.68	not included	
Amenity Land I	0.00664	1.52	0.01843	2.51
Amenity Land II	0.00625	3.52	0.00021	0.04
Industrial Land	0.05184	1.77	0.00406	0.28
New Construction*	0.02260	1.94	0.15881	2.58
Land value function				
β_1	0.03299	3.26	0.00006	7.27
β_2	-0.11966	-3.58	-0.17655	-0.95
β_3	0.05523	3.39	-0.05023	-0.48
β_4	4.31092	27.75	3.99973	2.82
Transformation variables				
λ	0.21918	5.56	0.31712	1.32
ψ	-0.31622	-3.37	0.24335	2.96
ξ	0.12286	2.9	1.02445	34.15

Table B.1: Hedonic Functions for Reading and Darlington

C. Demand system estimates

	Area	Bedrms	WC's	Width	Sq. Ft.	Floors	Ethnic	Bl Collar	Altitude
α	37.079	6.383	6.542	3.762	6.306	6.682	2.424	1.244	-0.086
t	*2.54*	*0.58*	*0.63*	*0.98*	*0.30*	*0.49*	*0.45*	*0.45*	*-0.04*
γ	-12.856	-3.915	-3.279	-1.814	-8.143	-3.772	-1.264	-0.879	-0.524
t	*-5.33*	*-2.03*	*-1.86*	*-2.80*	*-2.21*	*-1.58*	*-1.40*	*-1.89*	*-1.52*
δ	3.517	3.862	3.623	1.331	7.680	4.278	1.527	0.855	0.637
t	*14.52*	*23.03*	*22.87*	*22.74*	*23.73*	*21.45*	*18.50*	*20.51*	*22.35*
P_{Land}	-1.019	0.409	0.296	0.065	0.848	0.213	0.071	0.059	0.031
t	*-1.84*	*1.34*	*0.99*	*0.58*	*1.37*	*0.54*	*0.48*	*0.75*	*0.55*
P_{Beds}	2.111	0.011	0.497	0.284	1.632	0.552	0.170	0.108	0.120
t	*2.51*	*0.02*	*0.84*	*1.28*	*1.33*	*0.76*	*0.58*	*0.68*	*1.09*
P_{WC}	0.318	-0.295	-1.216	-0.090	-0.336	-0.286	-0.105	-0.030	-0.065
t	*0.48*	*-0.75*	*-3.26*	*-0.63*	*-0.42*	*-0.59*	*-0.56*	*-0.29*	*-0.93*
P_{Width}	-0.671	0.338	0.353	-0.187	0.624	0.752	0.282	0.130	0.102
t	*-1.26*	*0.86*	*0.91*	*-1.28*	*0.83*	*1.61*	*1.51*	*1.39*	*1.47*
P_{SqFt}	1.197	1.161	1.450	0.582	0.668	1.718	0.795	0.400	0.216
t	*1.14*	*1.54*	*2.02*	*2.17*	*0.45*	*1.95*	*2.13*	*2.13*	*1.61*
P_{Floors}	1.160	0.979	0.773	0.356	2.057	0.083	0.262	0.253	0.125
t	*1.14*	*1.23*	*1.05*	*1.30*	*1.32*	*0.08*	*0.67*	*1.27*	*0.87*
P_{Ethnic}	1.017	-0.265	-0.206	-0.006	-0.476	-0.346	-0.318	-0.050	-0.040
t	*3.57*	*-1.33*	*-1.07*	*-0.08*	*-1.19*	*-1.43*	*-4.07*	*-1.06*	*-1.21*
$P_{BlCollar}$	0.228	0.432	0.364	0.127	0.876	0.444	0.168	-0.117	0.055
t	*0.48*	*1.24*	*1.12*	*1.01*	*1.28*	*1.06*	*1.00*	*-1.39*	*0.89*
$P_{Altitude}$	-0.755	0.305	0.099	-0.040	0.541	0.264	0.046	0.036	-0.112
t	*-1.61*	*1.07*	*0.37*	*-0.36*	*0.97*	*0.78*	*0.36*	*0.51*	*-2.20*
P_{Amen1}	0.028	0.058	0.065	0.015	0.080	0.119	0.082	0.031	0.018
t	*0.17*	*0.54*	*0.66*	*0.38*	*0.38*	*0.94*	*1.65*	*1.17*	*0.98*
P_{Amen2}	0.087	-0.008	-0.003	0.001	-0.015	-0.002	-0.003	0.000	-0.001
t	*3.65*	*-0.44*	*-0.16*	*0.07*	*-0.42*	*-0.08*	*-0.41*	*0.00*	*-0.16*
P_{Indus}	5.703	-1.082	-0.841	0.051	-1.955	-1.424	-0.636	-0.255	-0.191
t	*4.16*	*-1.47*	*-1.17*	*0.18*	*-1.33*	*-1.61*	*-1.56*	*-1.38*	*-1.45*
Adj. R^2	0.95	0.97	0.98	0.98	0.98	0.97	0.97	0.97	0.97

Table C.1: Reading Demand System - Non-Planning Characteristics

	Amenity 1	Amenity 2	Ind Land
α	-1.304	-2.303	3.919
t	*-0.92*	*-1.17*	*0.32*
γ	-0.106	0.247	-3.844
t	*-0.43*	*0.73*	*-1.80*
δ	0.426	0.183	4.073
t	*22.36*	*5.05*	*22.42*
P_{Land}	0.004	-0.084	0.317
t	*0.09*	*-1.11*	*0.91*
P_{Beds}	0.063	0.126	0.581
t	*1.00*	*1.11*	*0.86*
P_{WC}	-0.082	-0.134	-0.256
t	*-1.79*	*-1.65*	*-0.58*
P_{Width}	0.075	0.113	0.565
t	*1.39*	*1.34*	*1.34*
P_{SqFt}	0.073	-0.021	1.461
t	*0.81*	*-0.14*	*1.80*
P_{Floors}	-0.037	-0.117	0.964
t	*-0.38*	*-0.82*	*1.08*
P_{Ethnic}	-0.009	0.050	-0.317
t	*-0.44*	*1.45*	*-1.45*
$P_{BlCollar}$	0.009	-0.094	0.404
t	*0.21*	*-1.46*	*1.05*
$P_{Altitude}$	0.007	-0.149	0.274
t	*0.19*	*-2.31*	*0.88*
P_{Amen1}	-0.082	0.022	0.106
t	*-6.11*	*0.95*	*0.92*
P_{Amen2}	-0.001	-0.052	-0.004
t	*-0.28*	*-13.99*	*-0.20*
P_{Indus}	-0.121	0.040	-2.022
t	*-1.36*	*0.21*	*-2.42*
Adj. R^2	0.97	0.85	0.97

Table C.2: Reading Demand – Planning Amenities

	Area	Bedrms	WC's	Width	Sq. Ft.	Floors	Ethnic	Bl Collar
α	26.717	65.090	29.234	3.634	3.929	57.534	13.623	31.863
t	*0.63*	*0.55*	*0.94*	*0.37*	*0.18*	*0.34*	*0.50*	*0.58*
γ	-13.738	9.748	0.566	0.550	2.001	16.581	2.146	2.726
t	*-2.72*	*0.83*	*0.18*	*0.52*	*0.88*	*0.90*	*0.73*	*0.49*
δ	11.011	6.686	1.809	0.748	1.395	9.463	1.609	3.754
t	*7.06*	*2.84*	*2.93*	*3.79*	*3.05*	*2.78*	*2.79*	*3.23*
P_{Land}	3.460	13.957	4.250	1.244	2.590	20.385	3.502	6.998
t	*1.10*	*1.97*	*2.23*	*2.07*	*1.92*	*2.01*	*2.12*	*2.13*
P_{Beds}	3.092	-14.364	-2.070	-0.653	-1.836	-13.084	-2.258	-4.607
t	*1.20*	*-2.99*	*-1.57*	*-1.65*	*-1.98*	*-1.96*	*-2.10*	*-2.10*
P_{WC}	-0.051	-0.544	-0.416	-0.060	-0.120	-0.935	-0.143	-0.368
t	*-0.19*	*-0.93*	*-3.51*	*-1.23*	*-1.07*	*-1.12*	*-1.04*	*-1.21*
P_{Width}	-3.348	3.535	0.865	-0.172	0.629	4.074	0.712	1.367
t	*-1.29*	*0.69*	*0.67*	*-0.40*	*0.63*	*0.56*	*0.58*	*0.57*
P_{SqFt}	0.244	9.181	2.024	0.652	0.775	10.533	2.009	4.534
t	*0.10*	*1.90*	*1.52*	*1.59*	*0.86*	*1.59*	*1.93*	*2.09*
P_{Floors}	2.727	-17.055	-3.627	-1.475	-3.465	-31.132	-4.150	-7.422
t	*0.67*	*-2.32*	*-1.75*	*-2.16*	*-2.32*	*-2.71*	*-2.21*	*-2.20*
P_{Ethnic}	-1.588	-1.961	-0.505	-0.234	-0.429	-3.874	-1.431	-0.962
t	*-0.80*	*-0.69*	*-0.67*	*-0.91*	*-0.75*	*-0.92*	*-2.23*	*-0.72*
$P_{BlCollar}$	1.729	-0.514	-0.047	-0.056	-0.130	-0.953	-0.131	-2.309
t	*1.26*	*-0.24*	*-0.09*	*-0.29*	*-0.31*	*-0.30*	*-0.26*	*-2.31*
P_{Amen1}	0.028	0.170	0.063	0.012	0.035	0.237	0.052	0.053
t	*0.26*	*0.67*	*0.93*	*0.59*	*0.70*	*0.63*	*0.82*	*0.43*
P_{Amen2}	0.054	-0.313	-0.078	-0.026	-0.060	-0.479	-0.077	-0.143
t	*0.73*	*-2.00*	*-1.97*	*-2.10*	*-2.01*	*-2.14*	*-2.08*	*-1.94*
P_{Indus}	3.616	-11.292	-2.235	-0.765	-2.064	-16.927	-2.507	-4.724
t	*1.58*	*-1.93*	*-1.60*	*-1.59*	*-1.85*	*-1.89*	*-1.81*	*-1.71*
Adj. R^2	0.89	0.53	0.60	0.70	0.54	0.48	0.50	0.64

Table C.3: Darlington Demand System – Non-Planning Characteristics

	Amenity 1	Amenity 2	Ind Land
α	-0.141	-0.070	1.496
t	*-0.01*	*-0.54*	*0.31*
γ	0.974	0.011	0.404
t	*0.89*	*0.66*	*0.79*
δ	0.608	0.004	0.266
t	*2.38*	*1.21*	*2.77*
P_{Land}	0.696	0.004	0.593
t	*1.16*	*0.55*	*2.07*
P_{Beds}	-0.895	0.003	-0.411
t	*-2.13*	*0.70*	*-2.16*
P_{WC}	-0.036	0.000	-0.027
t	*-0.70*	*0.47*	*-1.11*
P_{Width}	0.315	0.004	0.111
t	*0.68*	*0.74*	*0.54*
P_{SqFt}	0.721	-0.004	0.346
t	*1.74*	*-0.92*	*1.84*
P_{Floors}	-1.121	-0.010	-0.712
t	*-1.72*	*-0.90*	*-2.28*
P_{Ethnic}	-0.125	-0.003	-0.097
t	*-0.52*	*-1.40*	*-0.82*
$P_{BlCollar}$	-0.008	0.003	-0.032
t	*-0.03*	*1.37*	*-0.37*
P_{Amen1}	-0.139	0.001	0.008
t	*-6.23*	*1.83*	*0.72*
P_{Amen2}	-0.029	-0.002	-0.013
t	*-2.13*	*-10.90*	*-2.07*
P_{Indus}	-1.080	-0.009	-0.589
t	*-1.85*	*-1.28*	*-2.31*
Adj. R^2	0.66	0.75	0.49

Table C.4: Darlington Demand – Planning Amenities

Notes

[1]This paper draws upon research funded by the Economic and Social Research Council under award No. D00 23 2044. This support is gratefully acknowledged.

[2]For example, see Sheppard (1988), Fischel (1990), Epple, Romer, and Filimon (1988), Brueckner (1990), Brueckner (1995), and Brueckner (1996).

[3]For example, see Mayo and Sheppard (1991), Cheshire and Sheppard (1989), Bramley (1993b), Bramley (1993a), Gatzlaff and Smith (1993), and again Fischel (1990).

[4]Fewer than half the ten parameters used in Jackson, *et al.*

[5]In the budget share equation we regard land as one of the continuously variable characteristics of a house, and its price $\widehat{R}$ would be one of the prices denoted p_j.

[6]In this equation and those that follow, we use the notation I^* to denote the price index. In the original presentation of Deaton and Muellbauer, this index was given by:

$$\alpha_0 + \sum \alpha_k \ln p_k + \frac{1}{2} \sum_k \sum_l \gamma_{k,l} \ln p_k \ln p_l$$

In our calculations we have followed the same procedure used in estimation, and used Stone's price index as an approximation.

[7]Clearly, any monotonic transformation of the right hand side of 4.2 would serve as well. In our calculations we take this *particular* representation.

[8]As reported by the Automobile Association for 1984.

[9]Based on estimated mean travel speeds and sample mean incomes within each city.

[10]We use bold face to denote vectors or matrices with each row corresponding to an observation in our sample. A bar over the variable such as $\bar{\mathbf{u}}_1$ denotes the mean of the corresponding vector.

[11]These and all monetary figures given below are in 1984 pounds per annum unless otherwise noted.

[12]This amounts to about 894 square feet per household.

[13]In equation 6.4 we abuse the notation somewhat. We have written the price vector with the price of land separately, so that the expenditure function, which depends on the utility level and prices is written $c(u, r, p)$.

[14]A tax on real property which was tied to property values. The tax was eliminated in favor of the 'community charge', which itself was eliminated and replaced in 1992 by a modified property tax.

[15]About 6 or 7 times agricultural land values.

[16]Somewhat less than three households per acre within the urban area.

[17]For example, increases in prices of other goods resulting from increased land prices or suboptimal location of production.