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Taxes Versus Regulation:
The Welfare Impacts of Policies for Containing Sprawl

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Our central concern in this paper is to examine some alternative policies for physically containing the growth of urban areas. We undertake a microsimulation to provide a comparison between land use planning policies that enforce an urban growth boundary and policies that limit development at the periphery using taxes. We parameterise our microsimulation using the structure of demand and policy implemented in a rapidly growing city in the south of England. We make no judgment as to the optimality or otherwise of the existing degree of constraint: we take that as datum and analyse only the welfare costs, distributional impacts and effects on urban densities of alternative ways of achieving the currently observed degree of constraint. The methodology we deploy to address these issues could be turned to a wide range of other urban modeling purposes. It has the advantage of being clearly founded in microeconomic theory and applies observed behavioural relationships, estimated from the relevant economic data. We find that the use of a tax on land could produce the same limitation on growth as existing regulatory policies but provide higher equilibrium welfare levels. We find that the use of a tax on transport costs, however, while capable of producing a compact urban form, would not raise welfare when compared with regulatory approaches.

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1. Introduction[1]

One of the paradoxes of urban economic development is that resident households desire the personal consumption of space in all of its pleasant varieties, and strive to limit the indulgence of this desire exhibited by their fellow citizens. Each household seeks to consume private space as a location and surrounding garden for a residence, and can generally be expected to devote a considerable portion of income towards its acquisition. When others do this, however, the process is sometimes strenuously opposed and decried as 'sprawl'. The tension is made more severe in times of rising incomes and/or falling transportation costs because these tend to encourage an increase in private consumption of land.

Part of the rationale for this tension is that private consumption of space is not the only way that space can generate utility for the household. Open space is an alternative use that is valued by nearby households. It may be available both in the form of a public good that is accessible to local households, and in the form of private use (by other consumers or producers) that provides external benefits in the form of visual amenity or spatial separation from noxious uses. The public good nature of open space suggests that without policy intervention, it will be underprovided.

Our central concern in this paper is to examine some alternative policies for implementing development controls. We undertake a microsimulation to provide a comparison between land use planning policies that enforce an urban growth boundary and policies that limit development at the periphery using taxes. We parameterise our microsimulation using the structure of demand and policy implemented in a rapidly growing city in the south of England.

One (optimistic) way to understand the tension over urban development is to regard zoning and concerns over sprawl as part of the community struggle to ensure an optimal provision of the public benefits of open space. Of course, policies that limit urban development can also increase the wealth of the owners of residential property within the constrained communities, so that it is also possible that development controls are simply rent seeking activities. The efficiency of the actual level of development control chosen is not addressed here but is taken as datum. It is the focus of the analysis reported in Cheshire and Sheppard [2002].

That households value both private land consumption and the different varieties of open space seems clear. Amongst others, Cheshire and Sheppard [1995] and [1999] have quantified the impact on land values and the structure of demand for accessible open space, inaccessible open space, and private land

[1] We would like to thank the Leverhulme Foundation for its support for the work underlying this paper.

consumption. Naturally, the fact that open space is valuable does not demonstrate that it is underprovided (or overprovided).

The **efficiency** of urban development is central to the concept of 'sprawl'. Brueckner [2001] and Brueckner and Kim [2000] take this as a starting point and provide a useful economic evaluation of the various reasons for public concern over 'sprawl'. It is worth noting the concerns they identify as the sources of the inefficiency associated with sprawl, because these indicate the relevant potential policy responses. The primary sources of economic inefficiency associated with sprawl are the loss of public good amenities arising from the development of open space at the periphery, and the increase in commuting (and associated pollution and congestion) that comes with low-density development.

A standard economic response would be to design policies that rely on taxation of any inefficient activities (whether commuting or development of peripheral land) in order to internalise the external costs. In Britain, and increasingly in the United States, land use policies have generally not relied on taxation. Instead direct regulation of land development has been employed. In the British context this comes via the Town and Country Planning System that provides a national framework for local and regional regulation of land use and urban development. In the United States the call for 'smart growth' policies such as urban growth boundaries (UGBs) has become more pronounced, and such boundaries have been extensively applied in some areas. A useful taxonomy and discussion of these policies in the U.S. is presented in Downs [2001]. In Britain, many of these policies have been employed for decades. We suggest that a closer examination of the UK context can contribute to our understanding of how such policies might work, and what alternatives are available.

There have been numerous proponents of the use of tax incentive policies for containing urban development. For example, American Farmland Trust [1997] advocates 'differential assessment' as a means of preserving land in agricultural use at the urban periphery. Essentially, this means application of lower property tax rates to land in agricultural use, and raising the rate if the land is converted to urban use. The difference between the agricultural and residential rate provides a direct tax on the process of urban land conversion at the periphery.

This sort of differential assessment is to some extent used in the UK although the land use consequences are minimal because the levels of property taxation ("Council tax") are low even for land in urban use and are not directly related to the area of land used for residential purposes. Land in purely agricultural use (such as cropland) is not subject to rates, although 'non-agricultural' activities on farms are subject to business rates. Proposals have been put forward by the Department of Environment, Transport, and Regions [2000] to provide reduced or eliminated taxation for these non-agricultural activities on small farms. Land in urban use (such as for residential purposes) is subject to a tax that varies with the value of the property (including structure) and across local authorities. The average annual tax over all authorities and types of residential properties is on the order of ₤650 (about $1000) per annum.

Commuting is also taxed (both in the UK and the United States) in the form of taxes on fuel and vehicles, and such increases in the operating cost per mile increase the incentives to live near the urban centre (or at least near employment centres). Whether these taxes have a measurable impact on actual land use patterns is less obvious, but proponents of higher fuel taxation often cite the reduction in commuting and the more compact urban form such taxes would be expected to generate.

Both differential rates of land taxation and taxation on commuting seem to offer alternatives to the regulatory maintenance of an urban growth boundary. If we are to contemplate the policy alternative of using land taxation or taxation of commuting as an alternative mechanism for limiting urban sprawl, we must answer several questions:

- Is it possible? That is, can we find levels of taxation that, when applied in an urban context produce an equilibrium that uses the same amount of land as is produced by the regulatory approach of the UGB?
- What levels of taxation are required (and implicitly, would they be politically feasible)?
- Would these alternative policies increase or reduce the average welfare level compared to imposing a UGB?
- What are the potential distributional consequences of alternative policies?
- What impact might such taxes have on densities and the physical form of cities?

Our analysis below addresses these questions regarding the alternative policies of using differential land taxation and using *ad valorem* taxation on the ‘operating costs’ of transport as mechanisms to restrict the urban area to one that uses the same amount of land as is used in the *status quo*. One aspect of using taxation for such policies is the revenue raised. We assume that the revenues are spent locally with efficiency and equality (so that they are equivalent to an equal income transfer to each household that exhausts the total revenue raised). Other assumptions are clearly possible, including the polar extreme in which none of the tax revenues are returned to the community. Although they are not presented below, we have examined this polar extreme case and while it is certainly less attractive from a welfare perspective the basic quality of the results is not greatly affected.

Before proceeding to our analysis, we pause to inquire whether the welfare impacts or relative merits of alternative policies are either obvious or implied by theoretical considerations. An initial reaction might follow one of two opposing arguments. On the one hand there is a relatively standard price theory argument indicating that imposing a tax on a commodity and then rebating the amount of the tax collected back to the consumer (equivalent to maximal efficiency in public expenditure) will never make the consumer better off.

An alternative argument is derived from a focus on revenue raised from the tax and a comparison with the existing system. With an UGB or other planning constraint, the 'tax' imposed on urban residents is implicit. These come in the form of either more expensive land (and hence housing) resulting from the reduced supply of land for private residential consumption within the urban area, or in the form of increased commuting costs resulting from choice of location outside of the constrained area and commuting 'across the greenbelt' or from neighboring jurisdictions. The tax 'revenues' in this case are not used to provide local public goods nor rebated to all households within the urban area, but rather accrue as capital gains to owners of land with planning permission (many of whom may reside outside the urban area), as incomes for lawyers who specialize in planning appeals, or as incomes to those who provide transport services. This argument suggests that since the anti-sprawl tax policies we consider below incorporate local expenditure of tax revenues in the form of rebates, they must of necessity generate higher welfare for urban residents.

There are some difficulties with both of these arguments. The first argument compares the situation with constrained land use to a situation with unconstrained land consumption, and fails to consider the public good value of a reduction in urban sprawl. It also neglects redistributive impacts of tax policies. A tax on land in urban use, for example, may generate disproportionate revenue from more affluent consumers of housing with large lots. Equal rebates to each household (or public expenditures available to all residents equally) could provide a net transfer to lower income residents that results in an increase in average welfare levels.

The second argument may be excessively optimistic in expecting an inevitable increase in welfare. When choosing between anti-sprawl policies it might be helpful to ask which is likely to be associated with the least 'deadweight loss'. The relative elasticity of demand of the aspect of consumption that is taxed (whether explicitly or implicitly) will determine the cost of achieving any anti-sprawl benefits. In this situation it is possible that a policy regime may make inefficient use of 'revenues' but be preferable to an alternative that spends revenues more efficiently but generates them from a less efficient tax.

These observations suggest the appropriateness of using a microsimulation exercise as the basis of our analysis. The desirability of alternative policies will depend on the structure of demand and the distribution of income. These factors can be accounted for within the simulation, and the relative merits of alternative policies evaluated.

Our microsimulation utilises a modified ‘monocentric’ model comprised of individuals whose demand is based on the demand system whose estimates are presented below. While the model is similar to models familiar from the urban economics literature, it incorporates a variety of features that permit representation of some of the complexities of the actual urban area whose housing market and setting are used to estimate the structure of demand and parameterise the model. In the next section we describe these data, and in the following section we present our analysis of the structure of demand for house characteristics and neighbourhood amenities. Making central use of the demand for private residential land, this structure is then used in sections 4, 5 and 6 to present estimates of the baseline level of land use regulation and to examine two fiscal alternatives to this regulation. Section 7 provides a summary of our results and some concluding remarks on the viability and desirability of these policy options.

2. Data and Setting

Our data are drawn from the urban area of Reading, England. The city is located on the Thames about 35 miles west of central London. Reading is subject to considerable pressure for growth and residential development, and in response has adopted some of the most restrictive planning policies in the United Kingdom. With frequent high-speed rail links to London, proximity to Heathrow airport and other location advantages the area has attracted a number of technology firms[2] and more generally follows the development patterns typical of prosperous, middle-size cities of the southeast of England. Despite its proximity to London, Reading is a major employment centre with more than 85 percent of its employed residents working locally and a strong central business district employment concentration.

The city had in 1991 a metro area population of approximately 337000 persons comprising 129000 households. At the time of the 1993 survey we estimate that there were 131370 households. Our initial sample of properties comprised over 870 separate structures. This provided a sample of approximately 20% of the residential properties offered for sale by major estate agents in the autumn of 1993. Postal surveys with follow up were directed to each address in the sample to collect information on the actual sales price of the structure, and the income and demographic composition of the household. Responses from approximately 461 households were ultimately obtained, with complete response (including income and family structure) from 310 households.

[2] Microsoft, Oracle, Hewlett-Packard and others

Supplemental information on land use was assembled from Ordnance Survey resources and aerial photographs. Data on secondary school catchment areas and school quality was obtained from the local education authorities. Census data from 1991 were used for the ethnic and socio-economic characteristics of local neighbourhoods.

3. Hedonic Analysis of Demand

In order to estimate the structure of demand for land and open space, we must first obtain estimates of the implicit prices of land and other structure and neighbourhood attributes. We do this by estimating the modified linear Box-Cox hedonic price function given in equation (1). Note that the value function for urban residential land, specified in equation (2), is estimated directly as part of the hedonic price function. The land rent is 'monotonic' only in the sense that it is radially symmetric: land value must increase or decrease at the same rate in any given direction away from the urban centre.

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

where:

P	=	rentalised price of structure
q_i, q_j	=	structure or location specific characteristics
$K, \beta_i, \beta_j, \lambda, \psi, \xi$	=	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
λ, ψ, ξ		are the standard parameters of the Box-Cox functional form.

$$r(x,\theta) = \beta_1 \cdot e^{x \cdot (\beta_2 + \beta_3 \cdot \mathbf{sin}(n \cdot \theta - \beta_4))} \qquad (2)$$

Where		
x	=	Distance from the city center
θ	=	Angle of deflection from the city center
n	=	Number of 'ridges' in land value, representing radial asymmetries
β_i	=	Estimated parameters of land value function

The estimated parameters for the hedonic price function are presented in Appendix Table 1 below. Searching over a small grid (1-4) it was determined that a rent function with n=3 ridges provided the best fit to the data. The estimated land value depends on the location and also the size of the lot and type of structure built upon it. For a structure matching the sample mean in all attributes (except location) the spatial structure of the land value function is illustrated below in Figure 1. The surface is viewed from the southeast looking towards the northwest, and projected on the land value surface are the locations of sample observations and major transport routes. This measure of the value of land is essentially the price of 'land as pure space with accessibility'. Actual market prices of vacant land include the capitalized value of all the local amenities, neighbourhood characteristics and local public goods to which occupation of the land gives access. As was shown in Cheshire and Sheppard 1998 these amenity values may exceed the value of land as pure space with accessibility[3]. The land tax analysed below is a tax on the value of 'land as pure space with accessibility' and so might most usefully be called a *pure land tax*.

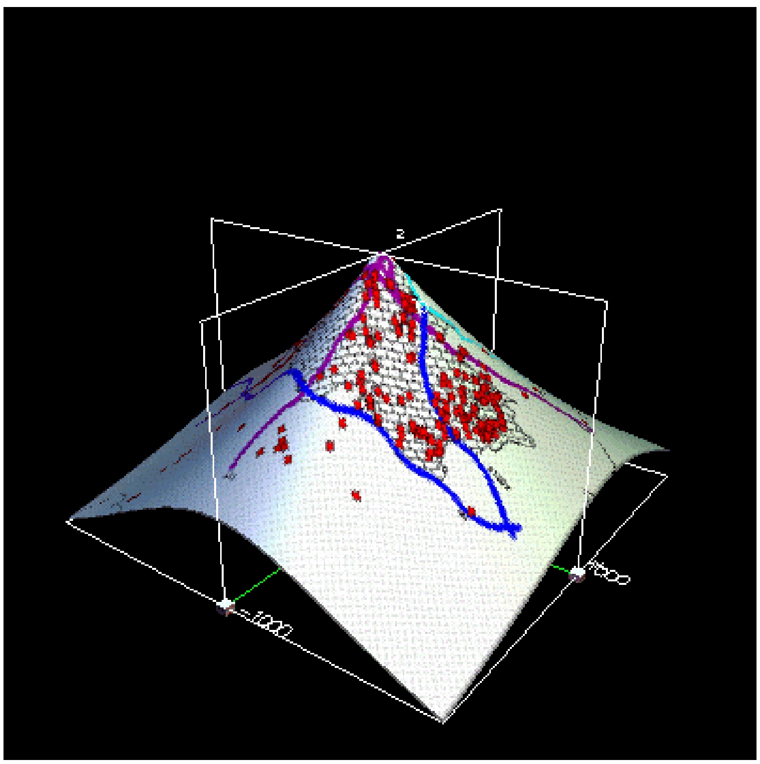

Figure 1: Estimated Land Value Surface Viewed From Southeast

Appendix Table 2 provides some descriptive statistics for the sample and the estimated attribute prices and expenditure shares for structure and neighbourhood attributes. These are used in estimating the demand system, which in turn is used as the basis of our microsimulation.

We begin with a basic Almost Ideal Demand System linearised in the fashion suggested by Deaton and Muellbauer [1980]:

[3] In the data studied in Cheshire and Sheppard (1998) the amenity values were greater by a factor of up to eight.

$$w_i = (\alpha_i - \delta_i\alpha_0) + \sum_{j \in C} \gamma_{ij} \cdot \ln p_j + \sum_{k \in D} \gamma_{ik} \cdot \ln p_k + \delta_i \ln\left(\frac{M}{I^*}\right) \quad (3)$$

We then adapt this to capture the effects of household demographic structure, and to take account of the fact that there is no in-sample variation in the prices of those attributes that are measured in a dichotomous fashion. Some further discussion is presented in Cheshire and Sheppard [1998] and [2002]. The final demand system to be estimated is presented in equation (4).

$$w_i = \overline{\alpha_i} + \overline{\gamma_i} \cdot \ln \hat{P} + \nu_{a_i} A + \nu_{b_i} B + \delta_i \ln\left(\frac{M}{I^*}\right) + \sum_{j \in C} \gamma_{ij} \cdot \ln p_j \quad (4)$$

Where:		
w_i	=	Expenditure share on attribute i
ν_{ai}, ν_{bi}, δ_i and γ_{ij}	=	Demand system parameters to be estimated
$\hat{P}$	=	Structure value estimated using the hedonic price function
$\overline{\alpha_i}$	=	$(\alpha_i - \delta_i\alpha_0) + \sum_{k \in D} \gamma_{ik} \cdot \ln p_k$ (demand parameters to be estimated)
$\overline{\gamma_i}$	=	$(1-\hat{\psi})\sum_{k \in D} \gamma_{ik}$ (demand parameters to be estimated)
A	=	Number of adults present in the household
B	=	Number of children present in the household
$\hat{\beta}_k, \hat{\psi}$	=	Estimated parameters from the hedonic price function
M	=	Household income
I^*	=	Stone's price index, $\ln I^* = \sum_i w_i \ln p_i$
p_j	=	Price of house attribute or local amenity estimated from hedonic
C	=	Indices of attributes that are 'continuously' variable
D	=	Indices of dichotomous attributes

In order to estimate this demand system using single-market data we construct instruments for attribute prices using the prices faced by the two nearest observations in the sample, plus the distance between the observation and these 'nearest neighbours'. The estimated demand system parameters are presented in Appendix tables 3 and 4. Particularly for those variable attributes, whose demand structure plays a central role in our analysis, the models work well.

4. Baseline Level of Development Control

Having estimated a demand system we have access to an indirect utility function and expenditure function based on the estimated parameters. We use this for analysis of policy alternatives, calculating new urban equilibria[4], and evaluating the welfare consequences of these policies. The first step in our analysis is to establish the baseline utility and structure of development control. We do this by constructing a 'representative agent' urban economy in which all households in the urban area are of a single household type whose demographic structure and income is equal to the sample mean for these variables. Letting land be indexed as good 1, with its price represented as r, the expenditure function associated with the demand system implies that the common utility level achieved by all of these households is:

$$u = \left(\frac{\ln(M - t(x,\theta)) - \ln(I^*) - A \cdot \sum_i \nu_{a_i} \ln p_i - B \cdot \sum_i \nu_{b_i} \ln p_i}{r^{\delta_1} \prod_{i \geq 2} p_i^{\delta_i}} \right) \tag{5}$$

All variables are as defined in equation (4), M is the (common) household income level, and the transport costs (with operating costs as estimated by the Automobile Association) are given by:

$$t(x,\theta) = \left(\tau_1 + \frac{\tau_2}{\tau_3 + \tau_4 \cdot x} \right) \cdot (1 + \tau_5 \cdot \sin(3 \cdot \theta + \tau_6)) \cdot x \tag{6}$$

with

$\tau_1 = 2.5$	Operating cost of £2.5 per 10 metres
$\tau_2 = 7200$	Annual cost of a 1 hour daily commute at mean income levels
$\tau_3 = 500$	Speed (tens of metres per hour) at edge of CBD
$\tau_4 = 4$	Increase in travel speed as distance from CBD increases
$\tau_5 = 0.0922$	Matches asymmetry in land rent function estimated from hedonic
$\tau_6 = 3.2674$	Based on estimated land rent function in hedonic

Using these transport cost parameters generates a land rent function derived from the expenditure function that matches the estimate obtained from the estimated hedonic. With these parameters we then obtain an estimated common utility level for the representative household in equilibrium. The expenditure function implies a land rent function for each utility level:

[4] The evidence in relation to the empirical realism of assuming equilibrium in this urban land market was discussed in Cheshire and Sheppard [2002]. In general the evidence was consistent with the land (housing) market being in or very close to equilibrium. Equilibrium, apart from being implicit in the estimation of any hedonic price function, has the further useful property for the present analysis in that it implies that all land made available for occupation by the planning system is in fact 'consumed'. As discussed below this allows us to infer the planning determined supply of housing land and model alternatives to that supply which would be consistent with the observed values of other relevant variables.

$$r(u,x,\theta,p,M)=\left(\frac{\ln(M-t(x,\theta))-\ln(I^*)-A\cdot\sum_i \nu_{a_i}\ln p_i-B\cdot\sum_i \nu_{b_i}\ln p_i}{u\cdot\prod_{i\geq 2} p_i^{\delta_i}}\right)^{\frac{1}{\delta_1}} \tag{7}$$

We solve for the utility level that generates a land rent function providing the best approximation to the observed pattern of land rents obtained in the sample. This provides an estimated *status quo* utility level of u = 15.0631.

We model development controls as consisting both of restrictions on the fraction of land within the urban area made available for development, denoted by ω, and an urban growth boundary modeled as a maximum extent of allowed development.

We capture the urban growth boundary by constructing a border at which residential land values fall to a particular level that would be set by the planning authority. Not only does this provide a representation of the *status quo* policy that closely matches the observed physical pattern of development, but it can also be justified by noting that defense of the urban growth boundary is itself a costly process. Allocation of resources within the Town and Country planning system will then be focused on those parts of the periphery under the most pressure for development. The result tends to produce a uniform value of residential land along the effective urban growth boundary, which itself then exhibits the same asymmetries as exist in the land value function.

The observations that are furthest from the CBD in our sample have estimated land rents that translate to a purchase price for land as pure space of approximately £88600 per acre (note this compares to a value of vacant agricultural land at the time of approximately £2000 per acre). We use this value to define the urban growth boundary for our simulation.

The final *status quo* planning parameter we require is an estimate of the share of land available within the built up area for private residential consumption, ω. We can solve for this from the standard equilibrium condition for an urban land market.

Let N be the number of households, r is the rent function defined in equation (7), h represents the compensated demand for land, χ_1 is the radius of the CBD and let $\chi(\theta)$ represent the distance (in each direction θ) from the CBD at which land value falls to the value that defines the urban growth boundary.

Then we have:

$$\omega = \frac{N}{\int_0^{2\pi}\int_{\chi_1}^{\chi(\theta)} \frac{x}{h(u, r(u, x, \theta, p, M), p)} dx\, d\theta} \tag{8}$$

Using the *status quo* utility level and taking sample mean prices for other attributes, we obtain an estimated internal space availability of ω=0.2568[5]. This implies that just over a quarter of land within the urban growth boundary is actually made available for private residential consumption.

In our analysis below, we assume that the parameter ω remains unchanged. The urban growth boundary represented by χ(θ) implies that the total area within the urban growth boundary is about 52553 acres. In solving for equilibria under alternative policies we impose the constraint that the total area of land devoted to urban uses remains unchanged.

5. Policy Alternative: Transport Taxation

The first alternative policy we consider is an *ad valorem* tax on the operating cost of transportation. We model this by changing the transport cost function to:

$$t(x, \theta) = \left(\tau_1 \cdot (1 + \text{tax}) + \frac{\tau_2}{\tau_3 + \tau_4 \cdot x} \right) \cdot (1 + \tau_5 \cdot \sin(3 \cdot \theta + \tau_6)) \cdot x \tag{9}$$

and then letting the boundary of the built up area be defined by the point at which land value falls to the price of agricultural land, taken to be £2000 per acre. Land consumption and land rents are those that would characterise our representative agent approximation of the Reading urban area using the demand system estimated from the sample collected from that area.

After allowing for changes in the spatial distribution of population, we calculate the total revenue generated from the tax and distribute this to households as an income transfer so that M becomes $M + \frac{\text{total revenues}}{N}$. This income transfer increases the demand for land (and other house attributes in our demand system) and requires a further adjustment in the tax and utility level to accommodate all households. What we seek is an equilibrium in which the total tax revenue is distributed back to households, urban equilibrium is achieved and the total land used in the urban area is equal to the land area devoted to urban uses in the *status quo*. Such an equilibrium will be characterised by a tax rate and an equilibrium utility level. The spatial density of households and land value function will in turn follow from these.

[5] This value differs from that reported in Cheshire and Sheppard [2002] primarily because of the difference in the way the UGB is estimated here. This difference – since it is consistent – only affects that absolute values and means that those for the welfare costs cannot strictly be compared with the values reported in Cheshire and Sheppard [2002].

Such an equilibrium does exist and is described by:

Utility	=	14.6179
Tax	=	6.21884

That is, to achieve the same level of urban land use using only a tax on the 'operating cost' portion of transportation would require a 622% tax on such costs. As a result of this, the utility level of the representative agent would fall from 15.0631 to 14.6179. We stress that this is not because the tax revenues are spent within the urban area itself. Indeed, discarding the revenues altogether would achieve the same sized total urban area with a lower tax rate but actually result in an even lower utility level.

The spatial structure of the equilibrium is illustrated in Figure 2 below. The heavy line indicates the maximum extent of urban land use under a policy of transport taxation, allowing the boundary to be set by the true agricultural land value. The thin line indicates the maximum extent in the *status quo* policy of an urban growth boundary. The circular line is for reference set at the distance of the furthest observation in our sample.

Imposing a tax on operating costs alone results in a somewhat more 'circular' pattern of land use because it increases the relative importance of part of transport costs that are less sensitive to travel speed. This was chosen for the simulation because it provides a better approximation to the type of fuel taxes or road user charges that have been proposed.

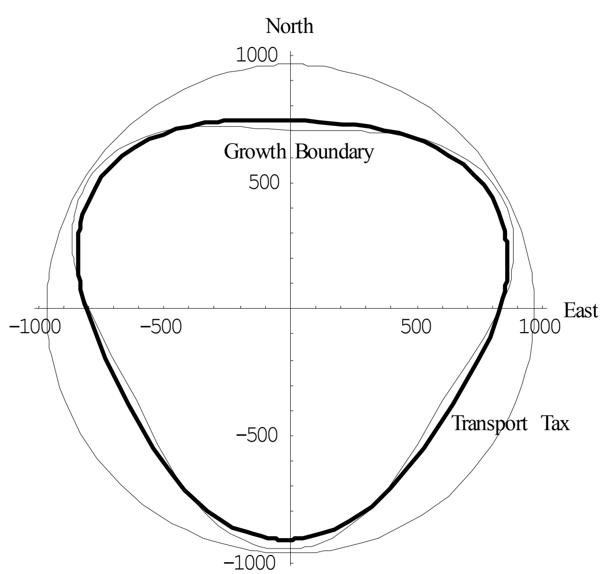

Figure 2: Urban Development With Transport Tax

The pattern of land values produced in this equilibrium is illustrated in Figure 3. Again the thin line represents the equilibrium pattern of land values in the *status quo*, while the heavy line represents the land value in equilibrium with a transport tax.

Note that the vertical scale is truncated. Under the transport tax the land value at the edge of the CBD rises to approximately £3 million (about a tenfold increase relative to that observed under the urban growth boundary).

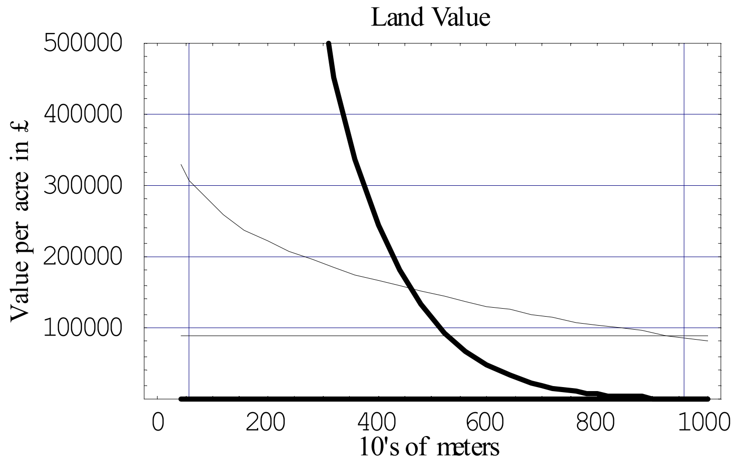

Figure 3: Land Values With a Transport Tax

Finally, Figure 4 presents the changes that would occur in the density of land use. As expected from such a severe change in land values, the change in equilibrium densities is substantial. The number of households per acre at the edge of the CBD would rise from the current value of just over 20 to more than 100.

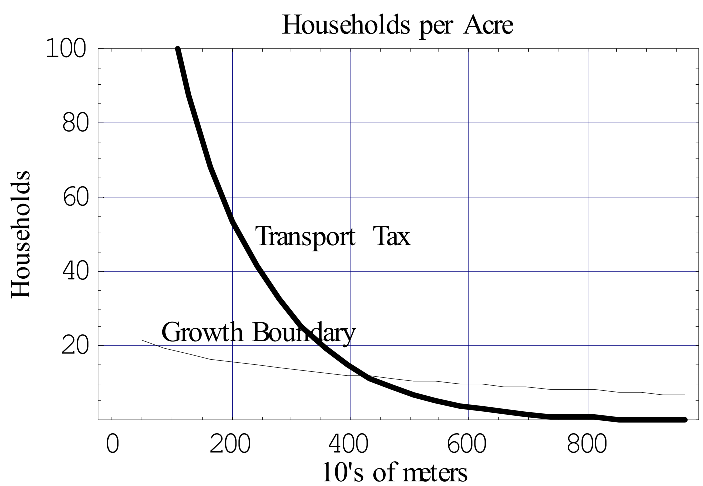

Figure 4: Residential Density With a Transport Tax

The tax revenues raised from this tax would be considerable. In equilibrium the tax would raise over £558 million. All of these calculations are based on the final equilibrium. Obviously transformation of land use of this order of magnitude would take many years to achieve, and its political acceptability is problematic.

6. Policy Alternative: Land Taxation

We next turn attention to a policy alternative based on differential taxation of land that assigns a per acre tax (in addition to the current rates) on all land in urban residential use. This tax can be avoided entirely by keeping the land in agricultural use and would serve to increase the opportunity cost of urban residential land.

Our microsimulation[6] is again based on a representative household model of the Reading urban area, and we further assume that the incidence of the property tax is fully borne by the residents. As before, we assume that all tax revenues are spent within the community and model this by rebating to each household an equal share of the total revenues collected by the pure land tax on residential land.

Equilibrium will be a standard urban equilibrium in which households must pay the value of land plus the tax, and the distance at which land value falls to the value of agricultural land plus the present value of the tax burden determines the boundary of development.

Such an equilibrium does exist and is described by:

Utility	=	15.3515
Tax	=	£3624.15 per acre

Thus the land taxation equilibrium that achieves the same level of urban land use as the *status quo* would actually increase household welfare levels. The tax that would achieve this represents a significant increase over existing rates, but could be argued to be manageable. At typical residential densities of 10-12 households per acre, the tax on residential land would represent an increase of approximately 50% in current Council tax levels. The associated increase in local expenditures could, at least, result in an increase in overall levels of welfare.

The pattern of equilibrium land values (and effective cost of land including the present value of the tax) is illustrated below in Figure 5. The thin line indicates the pattern of land values that prevails under the existing urban growth boundary policy. The lower heavy line indicates the equilibrium pattern of land

[6] All microsimulation calculations are done with *Mathematica* and the notebooks containing the models and calculations are available from the authors.

values, and the upper heavy line indicates the equilibrium land cost to households (land value plus the present value of the stream of required tax payments).

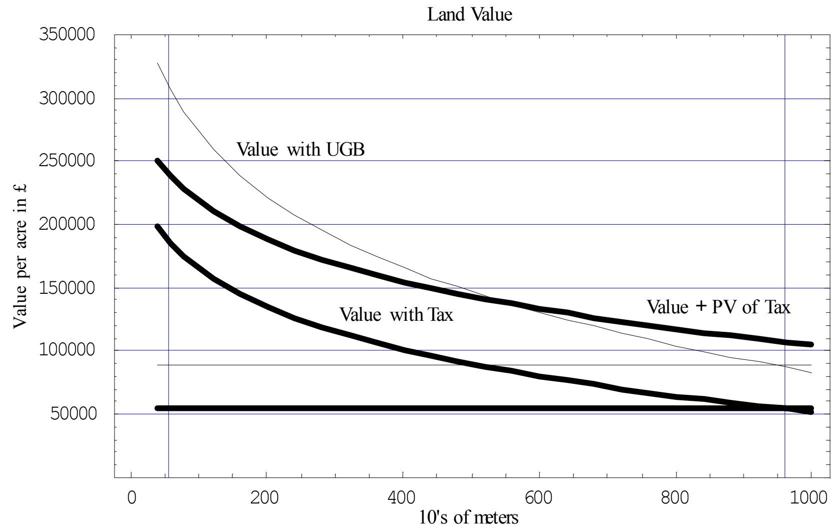

Figure 5: Land Value and Cost With a Land Tax

Figure 6 shows the equilibrium pattern of residential densities that emerge in equilibrium with a tax on land. While all policies achieve the same total amount of land in urban uses, the land tax produces a flatter density gradient than the urban growth boundary and much flatter than the transport tax.

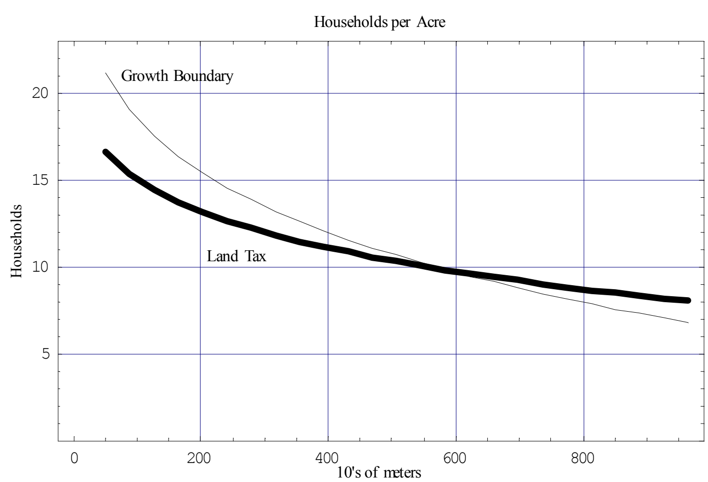

Figure 6: Residential Density With a Land Tax

The tax on residential land would produce less revenue than the transport tax - in equilibrium approximately £190.5 million per annum. Since the land tax increases the welfare level of the average household it seems reasonable to argue that it provides a more feasible policy alternative and dominates the existing policy based on urban growth boundaries.

We next provide some evaluation of the distributional effects of a land tax compared with maintaining the urban growth boundary. For this we must move away from our representative household model so that we can take account of the differences in income levels among households.

Using equation (5) above we obtain an estimate of the utility each household achieves in the status quo. From our calculations using the representative household model we have an estimate of the average change in utility level and the tax rebate received by each household. We assume that each household achieves the same proportionate increase in welfare level and the same income rebate. This allows us to calculate, using equation (7) the bid rent that could be expected of each household in an equilibrium with the land tax.

We then calculate, for each household, the amount of extra income that would be sufficient to generate the same utility level as they would, under these assumptions, achieve in an equilibrium where they faced the higher effective cost of land (land value plus tax) but received the benefit of the local tax expenditure. This equivalent variation in income will be positive on average, but not necessarily positive for each household. If a household's demographic structure, for example, leads it to demand large amounts of land then the local tax expenditure may be insufficient to compensate for the more costly land.

We calculate the average equivalent variation in income to be approximately £422 per annum. This ranges from a high of a gain of £11525 to a low of a loss of £10400. These are not small quantities, given that the sample mean income after taxes is £29560. Figure 7 presents a summary of the distributional impacts of the land tax.

The sample households are divided into income quintiles, and the vertical bars show the share of total sample income accruing to each share. The line indicates the share of total equivalent variation in income accruing to each quintile. Each quintile receives a positive net benefit (relative to the urban growth boundary) from the land tax policy. Furthermore, the poorest quintile receives the largest share so that the policy change is significantly progressive.

It should be stressed that the income quintiles represented here are for our sample, which is already restricted to owner-occupiers and hence drawn disproportionately from the most affluent two-thirds of the population. Nevertheless, it appears that switching from a land use policy based on an urban growth boundary to one based on land taxation could also contribute to a goal of reducing inequality.

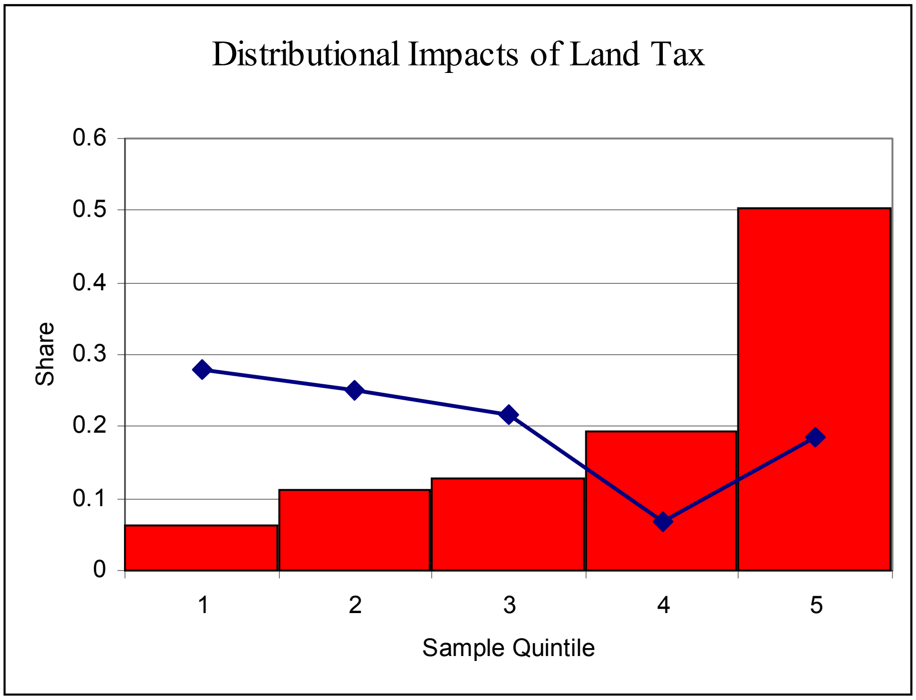

Figure 7

7. Conclusions

There are a variety of policies that societies might consider to limit the extent of urban development. Much recent interest has been devoted to urban growth boundaries and other 'smart growth' policies. Many British urban areas have been subject to such policies for long periods of time. We have collected data from one such area, estimated the structure of demand for land and other house and neighbourhood attributes, and used this estimated structure as the basis for a microsimulation of alternative land use policies to achieve the same total area of urban land.

We have considered two alternative policies: taxation of transportation and taxation of land. We found that both policy alternatives were capable of achieving the same level of urban land use as the status quo policy based on an urban growth boundary. While both policies could be used, there are very striking differences between them.

A policy of transport taxation would require very high levels of taxation to achieve the land use goals achieved by the urban growth boundary. Furthermore, it would actually reduce welfare levels relative to the status quo. It would modify the built form of the urban area to generate very much higher densities closer to the fringe of the CBD.

A policy of land taxation, on the other hand, could improve welfare levels and achieve the same levels of urban land use. While this would require significant increases in local property taxes, the levels required remain modest by the standards of many communities in North America. We also find that the land taxation policy would be strongly progressive relative to the urban growth boundary.

Our analysis suggests that communities in the UK and those in the US considering urban growth boundaries may well benefit from giving serious consideration to the use of land taxation as an alternative. This should not necessarily be taken as a positive recommendation for introducing such taxes, however. The analysis presented here takes as its 'datum' the status quo of very tight development constraint. As is shown in Cheshire and Sheppard [2002] this appears to represent a substantial net welfare cost relative to a more relaxed regulatory constraint on urban land supply - even allowing for the loss of open space amenities that would result. Nevertheless the results in the present paper do strongly suggest that attacking the perceived problem directly with a pure land tax would achieve a given growth constraint at lower welfare costs compared either to the present regulatory system or compared to a tax on the operating costs of vehicles. Since this latter tax might possibly generate additional social benefits over and above those of increasing the supply of unbuilt open space (such as a quasi tax on congestion and atmospheric pollution) it cannot be dismissed as strictly less efficient. The size of the tax necessary and the loss of welfare entailed are nevertheless suggestive.

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Appendix

Tables

Table 1: Estimated Hedonic Price Function

Continuous Attributes		*Dichotomous Attributes*	
Variable	**Estimate**	**Variable**	**Estimate**
Constant	0.430174	$ß_{CentralHeat}$	0.053347
t	*3.897*	*t*	*2.891*
$ß_{Bedrooms}$	0.029933	$ß_{Detached}$	0.221032
t	*1.884*	*t*	*4.614*
$ß_{WC}$	0.061056	$ß_{Semi\text{-}detached}$	0.118829
t	*4.115*	*t*	*3.436*
$ß_{SqFt}$	0.007858	$ß_{Terrace}$	0.02785
t	*4.184*	*t*	*1.102*
$ß_{SchoolGCSE}$	0.003901	$ß_{Wide\ through\ street}$	0.023627
t	*3.051*	*t*	*1.206*
$ß_{BlueCollar}$	0.02778	$ß_{B\text{-}Class\ road}$	0.016329
t	*2.350*	*t*	*0.153*
$ß_{Ethnic}$	0.010976	$ß_{A\text{-}class\ road}$	0.035196
t	*2.163*	*t*	*0.679*
$ß_{Industrial\ Land}$	0.004154	$ß_{Parking}$	0.033803
t	*2.686*	*t*	*1.498*
$ß_{AccessOpenSpace}$	0.003223	$ß_{SingleGarage}$	0.043101
t	*1.338*	*t*	*1.863*
$ß_{InaccessOpenSpace}$	0.000843	$ß_{DoubleGarage}$	0.081925
t	*1.049*	*t*	*2.334*
$ß_{Elevation}$	0.000464	$ß_{ThamesFrontage}$	0.339446
t	*0.496*	*t*	*4.618*
Land Value function		$ß_{LocalConstruction}$	0.007666
$ß_1$	0.064091	*t*	*0.416*
t	*3.210*	$ß_{Year2}$	0.027767
$ß_2$	-0.00083	*t*	*1.338*
t	*-2.304*	$ß_{Year5}$	0.047747
$ß_3$	-0.00014	*t*	*2.711*
t	*-1.113*	$ß_{Year6}$	0.110903
$ß_4$	-3.26736	*t*	*3.096*
t	*-4.623*		
Box-Cox parameters			
γ	-0.06941		
t	*-0.893*		
λ_1	0.840378		
t	*12.919*		
λ_3	0.208264		
t	*1.766*		
σ	0.119181	Log Likelihood	-712.489
t	*5.774*	Observations	461

Table 2: Descriptive Statistics, Prices, and Expenditure Shares for Sample

Variable	Mean	Std. Dev.	Min	Max	Description
ADULTS	1.897106	0.618811	1	4	Number of Adults
CHILDREN	0.858521	1.080285	0	4	Number of Children
MHAT	3.478157	2.757165	0.481737	13.70793	Income adjusted for hedonic
ESTPRICE	9.309626	5.241151	3.5389	45.36409	Structure price estimated from hedonic
SLAND	2.553258	1.332589	0.347236	7.96668	Expenditure share on land
SBEDS	2.203248	1.225636	0.164506	5.710995	Expenditure share on bedrooms
SWC	2.629387	1.744641	0.268627	8.951286	Expenditure share on WC's
SSQFT	9.142989	5.501154	0.735887	28.10168	Expenditure share on Sq Ft interior space
SBCOL	4.020366	2.107541	0.573379	12.98416	Expenditure share on avoid blue collar nbd
SAFIN	2.49594	1.446089	0.177507	7.706844	Expenditure share on avoid ethnic nbd
SINDU	5.416209	2.783108	0.741677	15.00779	Expenditure share on avoid local industrial land use
SAMEN1	1.144407	0.638904	0.10858	3.811946	Expenditure share on accessible open space
SAMEN2	0.327002	0.296338	0.009194	1.868709	Expenditure share on inaccessible open space
SALT	0.162774	0.128151	0.00366	0.760515	Expenditure share on local elevation
SGCSE	2.450426	1.51033	0.14816	9.290032	Expenditure share on school quality
SST2	0.077652	0.243186	0	1.457162	Expenditure share on street being wide through road
SST3	0.003255	0.040939	0	0.578579	Expenditure share on street being a "B" class road
SST4	0.021408	0.144846	0	1.450225	Expenditure share on street being an "A" class road
SSING	2.568107	3.61862	0	13.69357	Expenditure share on detached house
STERR	0.201016	0.411929	0	2.110691	Expenditure share on terrace house
SSEMI	0.822254	1.59143	0	8.925956	Expenditure share on semi-detached house
SCENTH	1.274579	0.877165	0	4.043052	Expenditure share on central heat
SOSPARK	0.157154	0.399491	0	2.521592	Expenditure share on off-street parking
SSINGAR	0.675341	0.791927	0	3.26653	Expenditure share on single garage
SDBLGAR	0.269837	0.814473	0	4.713673	Expenditure share on double garage
SYEAR2	0.099402	0.291666	0	1.720246	Expenditure share on built in 1915-45
SYEAR5	0.419968	0.723346	0	3.59282	Expenditure share on built in 1976-90
SYEAR6	0.116884	0.669945	0	6.458597	Expenditure share on built after 1990
SUNBLIT	0.171402	0.131037	0	0.580989	Expenditure share on avoid local construction
STHAMES	0.134007	1.175906	0	13.66355	Expenditure share on Thames frontage
SOTHER	60.44173	21.16822	0.616958	95.73976	Expenditure share on all other goods
ESTRENT	0.002552	0.001153	0.000365	0.010029	Price of land
PBEDS	0.018549	0.010449	0.007092	0.093752	Price of bedrooms
PWC	0.041927	0.022667	0.016158	0.198166	Price of WC's
PSQFT	0.002865	0.001505	0.001265	0.013277	Price of Sq Ft interior space
PBCOL	0.015259	0.009119	0.005348	0.079487	Price to avoid blue collar nbd
PAFIN	0.00555	0.003279	0.00216	0.028853	Price to avoid ethnic nbd
PINDU	0.001508	0.000921	0.000561	0.008065	Price to avoid local industrial land use
PAMEN1	0.001508	0.000928	0.000533	0.008111	Price of accessible open space
PAMEN2	0.0004	0.000228	0.000145	0.001819	Price of inaccessible open space
PALT	0.000225	0.000131	0.000073	0.001086	Price of local elevation
PGCSE	0.001639	0.000983	0.000585	0.008516	Price of school quality
PST2	0.017755	0.010922	0.006253	0.095678	Price of street being wide through road
PST3	0.012271	0.007549	0.004321	0.066124	Price of street being a "B" class road
PST4	0.026449	0.016271	0.009314	0.142526	Price of street being an "A" class road
PSING	0.166099	0.10218	0.058494	0.89507	Price of detached house
PTERR	0.020928	0.012875	0.00737	0.112779	Price of terrace house
PSEMI	0.089296	0.054933	0.031447	0.481199	Price of semi-detached house
PCENTH	0.040089	0.024662	0.014118	0.216029	Price of central heat

Table 2: Descriptive Statistics, Prices, and Expenditure Shares for Sample

Variable	Mean	Std. Dev.	Min	Max	Description
POSPARK	0.025402	0.015627	0.008946	0.136885	Price of off-street parking
PSINGAR	0.032389	0.019925	0.011406	0.174538	Price of single garage
PDBLGAR	0.061564	0.037873	0.021681	0.331756	Price of double garage
PYEAR2	0.020866	0.012836	0.007348	0.112443	Price of built in 1915-45
PYEAR5	0.03588	0.022073	0.012636	0.193352	Price of built in 1976-90
PYEAR6	0.08334	0.051269	0.02935	0.449102	Price of built after 1990
PNEWBLI	0.005761	0.003544	0.002029	0.031043	Price to avoid local construction
PTHAMES	0.255083	0.156921	0.089831	1.374588	Price of Thames frontage
DISTANCE	404.2577	194.6626	55.97321	964.3506	Distance to city centre
DIST1	24.55523	28.47504	1	220.0364	Distance to closest obs
DIST2	36.69851	34.67988	2.828427	288.3834	Distance to next closest obs

Table 3: Demand System for Variable Attributes

Coeff	Land	Bedrooms	WC's	Sq Ft	BlueCollar	Ethnic	Industrial	Acc Open	Inac Open	Elevation	Schools	Other
C	250.3682	-47.6037	-1.306	-362.6823	164.3365	139.1039	179.1604	20.308	-50.2145	32.3625	-62.8509	-681.9516
t	*1.3649*	*0.3453*	*0.007*	*0.5549*	*0.7678*	*0.9564*	*0.5762*	*0.2703*	*0.9776*	*1.3878*	*0.3527*	*0.3127*
Adults	0.0363	-0.0287	0.1001	-0.0396	-0.0833	-0.0033	-0.1297	-0.0139	-0.0355	-0.0137	-0.0922	0.533
t	*0.276*	*0.3051*	*0.8586*	*0.0894*	*0.5737*	*0.0323*	*0.648*	*0.2796*	*0.9731*	*0.9762*	*0.7687*	*0.3667*
Children	0.0883	0.018	0.0655	0.0881	0.0927	0.0839	0.1163	0.0249	0.0166	0.0059	0.039	-0.4953
t	*1.2616*	*0.3532*	*0.8736*	*0.3695*	*1.167*	*1.5623*	*1.041*	*0.9374*	*0.8339*	*0.6757*	*0.5708*	*0.6483*
Phat	-36.445	4.5796	0.1468	28.9345	-21.042	-20.261	-29.2063	-3.855	4.9479	-4.7004	5.9514	146.4294
t	*1.5431*	*0.2607*	*0.0062*	*0.3508*	*0.7538*	*1.0622*	*0.721*	*0.3983*	*0.7626*	*1.5793*	*0.2598*	*0.5249*
RealIncome	2.0194	1.8234	2.338	6.9748	3.6654	2.3693	4.692	1.0074	0.2765	0.1432	1.9106	-33.2789
t	*7.4843*	*9.4239*	*7.8117*	*7.6723*	*11.6022*	*10.8266*	*10.8891*	*9.0705*	*3.5874*	*4.6293*	*7.0187*	*11.0157*
P_{Land}	0.3821	-0.0312	-0.0806	-0.8273	-0.3391	-0.2663	-0.3662	-0.0474	-0.2173	-0.0537	-0.4481	1.3333
t	*1.3209*	*0.1708*	*0.2962*	*0.8066*	*1.1556*	*1.2365*	*0.8867*	*0.4532*	*2.3411*	*1.2746*	*1.8736*	*0.4942*
P_{Beds}	7.4977	-4.2708	8.0073	31.9157	2.8372	1.7733	-2.1743	-1.7504	5.039	-0.0332	3.9589	-57.6321
t	*1.0253*	*0.8045*	*1.1852*	*1.2806*	*0.3497*	*0.3249*	*0.1902*	*0.5727*	*2.2865*	*0.0349*	*0.5747*	*0.7112*
P_{WC}	7.1198	-0.033	-13.7845	0.2672	2.4272	3.5608	3.9743	1.0942	-1.606	1.0369	-6.1229	3.4064
t	*1.2801*	*0.0087*	*3.155*	*0.0153*	*0.3587*	*0.7564*	*0.4228*	*0.4783*	*1.0961*	*1.5731*	*1.2927*	*0.0529*
P_{SqFt}	0.7494	-7.5801	-3.4602	-91.0117	11.0336	10.6504	19.4912	4.4751	-5.5513	1.322	-1.4425	49.9913
t	*0.0582*	*0.7861*	*0.2644*	*1.9575*	*0.785*	*1.126*	*0.9767*	*0.8793*	*1.4112*	*0.8205*	*0.1199*	*0.3343*
P_{BCol}	1.8003	1.6741	1.4696	3.1319	-19.0582	-0.6488	2.4029	0.1854	-1.5957	0.5293	0.6219	-35.594
t	*0.4521*	*0.6207*	*0.3988*	*0.2298*	*4.0659*	*0.2044*	*0.393*	*0.1299*	*1.5816*	*1.2131*	*0.2001*	*0.8136*
P_{Ethnic}	3.1507	0.2874	1.9638	-0.9811	4.8826	-4.1688	4.6694	0.8886	0.6669	0.5855	-0.2271	-15.8936
t	*1.0569*	*0.1315*	*0.7441*	*0.0984*	*1.3231*	*1.8113*	*0.8933*	*0.7766*	*0.8559*	*1.6761*	*0.0978*	*0.4673*
P_{Indus}	9.9519	3.4031	0.0068	17.253	11.7468	4.525	-7.5015	3.135	-1.6852	1.3887	3.3691	-41.9581
t	*1.2414*	*0.6167*	*0.001*	*0.6184*	*1.3363*	*0.8397*	*0.6112*	*1.1096*	*0.7749*	*1.4616*	*0.501*	*0.4821*
$P_{AccOpen}$	-0.3671	-0.2673	2.3505	-0.6418	1.6524	1.2179	1.28	-5.3549	0.5458	0.0195	0.2695	-4.1436
t	*0.1815*	*0.2037*	*1.2459*	*0.1002*	*0.6868*	*0.7156*	*0.3899*	*7.2463*	*0.9769*	*0.0808*	*0.164*	*0.1903*
$P_{InaccOpen}$	0.4555	-0.3792	-0.4597	-2.4429	0.1399	0.0034	0.5406	-0.0472	-1.4005	0.0256	0.1553	5.9263
t	*0.6372*	*0.781*	*0.7268*	*1.0676*	*0.1834*	*0.0068*	*0.5107*	*0.1942*	*6.8727*	*0.3299*	*0.2586*	*0.7949*
P_{Elev}	-0.0484	0.1389	0.6505	0.8137	0.4105	0.5121	0.1706	-0.0527	0.186	-0.5309	0.3418	-8.2304
t	*0.1001*	*0.3958*	*1.3478*	*0.484*	*0.7867*	*1.4323*	*0.2284*	*0.2947*	*1.3268*	*7.6841*	*0.7767*	*1.4976*
P_{School}	3.7819	0.0762	0.4119	3.0036	0.9203	0.3846	1.2126	0.1863	0.0161	0.2206	-9.449	-6.8173
t	*3.4264*	*0.0865*	*0.3118*	*0.7517*	*0.7058*	*0.4623*	*0.6604*	*0.4639*	*0.0552*	*1.733*	*9.0378*	*0.5208*
R-squared:	0.6645	0.816	0.8239	0.784	0.8251	0.8231	0.8137	0.8172	0.4438	0.528	0.8183	0.8449
Adj R-square	0.6474	0.8066	0.8149	0.773	0.8162	0.8141	0.8042	0.8079	0.4155	0.504	0.8091	0.837

Table 4: Demand System for Dichotomous Attributes

Coeff	Street2	Street3	Street4	Detached	Terrace	Semi	CentHeat	Parking	1Garage	2Garage	BldYr2	BldYr5	BldYr6	LocalBld	Thames
C	35.7739	-20.061	47.233	-44.0347	26.1281	4.2479	-94.4885	38.0601	229.9393	-179.2325	-12.1724	-216.9441	112.6463	21.4531	572.4215
t	*0.4361*	*1.2461*	*1.4618*	*0.0707*	*0.2138*	*0.0095*	*0.4701*	*0.2962*	*0.9737*	*0.776*	*0.1265*	*1.07*	*0.5442*	*0.703*	*1.5773*
Adults	0.0305	0.0102	-0.028	0.1702	0.0344	-0.2905	0.0834	0.0135	0.0541	-0.1203	0.0174	-0.0411	-0.1292	-0.0266	-0.0075
t	*0.713*	*1.1535*	*1.4682*	*0.3947*	*0.4588*	*1.0428*	*0.6456*	*0.1566*	*0.3983*	*0.943*	*0.2898*	*0.3248*	*1.5778*	*1.2896*	*0.0499*
Children	0.0137	-0.0011	0.033	-0.1277	0.0102	0.0095	0.0622	0.0153	0.0716	-0.1583	-0.0072	-0.0218	-0.0274	-0.0051	-0.0109
t	*0.4444*	*0.3158*	*2.0019*	*0.4972*	*0.225*	*0.0548*	*0.8901*	*0.2914*	*0.8776*	*1.8956*	*0.208*	*0.2629*	*0.5761*	*0.4358*	*0.1083*
Phat	-4.6456	2.4285	-5.4224	9.0864	-1.7345	-11.0788	7.8477	-7.4301	-29.2275	22.0454	0.2151	30.9535	-12.9613	-3.4658	-72.0905
t	*0.4472*	*1.2258*	*1.314*	*0.1143*	*0.1101*	*0.1961*	*0.3093*	*0.4573*	*0.9726*	*0.7421*	*0.0175*	*1.1802*	*0.5104*	*0.8963*	*1.563*
RealIncome	0.0774	-0.0118	-0.0212	2.4503	0.1516	0.4488	0.9769	0.3367	0.7277	0.1786	0.071	-0.1082	0.3205	0.1967	0.2639
t	*0.8931*	*0.8958*	*0.4723*	*2.5464*	*0.739*	*0.8421*	*3.1335*	*1.8436*	*2.3956*	*0.5219*	*0.8242*	*0.3584*	*1.3197*	*3.9938*	*0.7197*
Pland	-0.14	0.0255	0.0121	-0.4107	0.3287	-0.5932	0.0404	0.1713	-0.1569	-0.1989	0.1098	0.4299	0.1784	-0.0859	1.2513
t	*1.3755*	*0.9296*	*0.1746*	*0.4033*	*1.9468*	*0.8959*	*0.1218*	*1.0948*	*0.4411*	*0.4756*	*0.7722*	*1.4309*	*0.566*	*1.7111*	*2.2631*
Pbeds	0.3296	0.4904	-0.1419	5.4514	-3.9888	0.6614	8.3736	3.9863	-7.1051	0.9016	2.0229	-5.3317	-0.6946	1.1038	-1.2271
t	*0.166*	*1.0226*	*0.1048*	*0.2183*	*1.0336*	*0.047*	*1.1822*	*1.0191*	*0.9684*	*0.117*	*0.6523*	*0.7171*	*0.0904*	*0.936*	*0.123*
PWC	-0.0762	-0.2904	-0.1757	-17.1066	0.5384	12.896	0.5641	3.0213	3.841	-1.5161	1.7121	-11.2445	-2.7244	0.9126	8.308
t	*0.0446*	*0.9589*	*0.2096*	*1.037*	*0.2063*	*1.1827*	*0.1115*	*1.2147*	*0.7011*	*0.2312*	*0.6335*	*2.1072*	*0.5118*	*1.2449*	*0.7101*
PSqFt	0.7581	-1.2345	2.6449	4.6832	4.7574	-28.1767	-13.8193	-0.562	21.9872	-18.6337	-4.0858	3.8208	7.6341	-2.6623	34.2212
t	*0.1389*	*1.2122*	*1.1464*	*0.105*	*0.5924*	*0.9179*	*0.9813*	*0.059*	*1.3685*	*1.2295*	*0.6485*	*0.2935*	*0.503*	*1.1797*	*1.5225*
PBCol	1.1129	-0.0889	-0.0156	-2.8658	-3.4337	25.2739	0.5282	1.701	5.3142	0.3937	0.8826	2.5076	2.5213	0.2568	10.993
t	*0.9095*	*0.4906*	*0.0277*	*0.2174*	*1.9913*	*3.0549*	*0.1697*	*0.8012*	*1.4514*	*0.0941*	*0.6108*	*0.6594*	*0.8688*	*0.3967*	*1.8285*
Pethnic	-0.298	-0.1582	-0.1798	6.6238	0.1323	-6.7524	0.5479	0.34	1.2591	-0.9515	0.0106	-3.8333	1.9708	0.1419	5.3224
t	*0.3496*	*0.9962*	*0.3077*	*0.8395*	*0.0882*	*1.2477*	*0.2083*	*0.2084*	*0.4304*	*0.327*	*0.0097*	*1.5716*	*1.005*	*0.3201*	*1.2928*
Pindus	0.7882	-1.1475	2.3728	-10.7632	4.1007	7.484	-2.0792	-1.9988	3.1139	-1.4945	-1.583	-10.4509	-0.4287	2.3716	6.0798
t	*0.2995*	*1.3212*	*1.5725*	*0.4298*	*0.9897*	*0.4341*	*0.2684*	*0.4879*	*0.3738*	*0.1704*	*0.4375*	*1.3543*	*0.0528*	*1.8871*	*0.4738*
PAccOpen	0.7908	0.0132	0.4418	3.0891	-0.066	-3.2463	-2.9233	0.0839	0.6476	-1.0636	0.2452	-2.1847	3.0344	0.1418	4.4352
t	*1.1302*	*0.1471*	*1.1974*	*0.4997*	*0.0674*	*0.6943*	*1.4656*	*0.0794*	*0.3137*	*0.5019*	*0.2856*	*1.0591*	*1.0384*	*0.446*	*1.4997*
PInaccOpen	0.4817	-0.0985	0.1659	-4.3366	0.0194	1.8522	-0.7596	-0.1327	0.59	-0.5968	-0.1241	-1.1469	0.1312	0.1184	1.3194
t	*1.8999*	*1.3233*	*1.3215*	*1.7383*	*0.0516*	*1.2253*	*1.0794*	*0.3301*	*0.8063*	*0.7438*	*0.3608*	*1.6632*	*0.1997*	*1.1149*	*1.2913*
Pelev	0.2515	0.0722	-0.1156	2.2318	-0.3891	0.1956	0.8207	0.0138	-0.1078	0.4943	0.0714	0.0163	0.7242	-0.0184	1.3773
t	*1.5504*	*1.2897*	*1.4735*	*1.2077*	*1.5346*	*0.1724*	*1.6431*	*0.0538*	*0.2032*	*0.7198*	*0.3561*	*0.0311*	*1.0568*	*0.188*	*1.2946*
Pschool	0.267	0.0164	0.4609	4.8599	-0.3753	-1.5614	-0.4804	0.5766	-0.3154	0.2515	0.5465	-2.5471	0.7894	0.6177	2.9461
t	*0.6844*	*0.3664*	*1.6709*	*1.2879*	*0.5521*	*0.6906*	*0.4412*	*0.7879*	*0.2653*	*0.2084*	*1.2702*	*2.2317*	*0.7321*	*3.3581*	*1.6869*
R-squared:	0.0829	-0.5947	-0.1741	0.4653	0.1461	-0.0969	0.3306	0.0005	0.0229	-0.1887	-0.0817	-0.2649	-0.0026	0.0836	-0.0369
Adj R-square	0.0363	-0.6758	-0.2337	0.4381	0.1027	-0.1527	0.2966	-0.0503	-0.0268	-0.2492	-0.1367	-0.3292	-0.0535	0.037	-0.0897