Chapter 8

The Rent Gradient

Economists have long relied on central place theory and its polycentric extensions to generate both rent (or price) and density gradients (Anas, Arnott and Small, 1998). Empirical specifications of rent gradients are based upon an assumed trade off of travel time and housing prices, in which travel cost rise and housing prices fall with increased access costs of economic centers. Results above show that household travel times do decrease with access to economic centers in the study area. Determining whether that increase is of magnitude large enough to support rent gradients is the purpose of this chapter. To make this determination a rent gradient is estimated using data from Maryland, the only portion of the study area for which housing price information is available. The gradient is a polycentric one, in which the influence subcenters on housing price is included in the estimation. These results are then examined in conjunction with the previous finding of increasing household travel time with access to economic centers.

The Theory

Equation (6) of the theoretical model shows the rationale for rent gradients.

$$c(y)\frac{\partial t}{\partial k} = -p_k h \qquad (6)$$

The rent gradient is the result of the assumption that travel time is an increasing function of access to economic centers, where k is a measure of the access to those centers and t is household travel time. On the basis of this assumption, the price of housing (p) is a declining function of k (or $p_k < 0$).

While the theory behind rent gradients purports that housing prices are a decreasing function of access to economic centers, economists acknowledge that neighborhood characteristics also influence housing prices. To both remove these effects and to determine their influence estimations of rent gradients may include neighborhood characteristics variables (Heikkila, et al., 1989; Waddell, Berry and Hoch, 1993).

The Data

The data used for estimating the rent gradient are drawn from the same sources as identified in Table 4.1 above. For clarity as full listing of the data and their sources are set out in Table 8.1 below. Summary statistics for the variables appear in Appendix 8A.

Table 8.1 Data Sources and a Description of the Data Used to Estimate the Rent Gradient

Data from the Census Transportation Planning Package

Variable Name	*Description*
Hcbd	travel time the CBD in hours
Nrst	travel time to the nearest subcenter in hours
Rpnwht	percent nonwhite

Data from Census Tiger/Line Files *(by block group)*

Variable Name	*Description*
Chage	average home age
Cavrms	average rooms per dwelling

Data from Maryland Department of Assessments and Taxation *(by house)*

Variable Name	*Description*
Asvt	Assessed value of the land and improvements (in thousands of dollars)
Ltsza	Lot size (in acres)
Hsszh	House size (in hundreds of square feet)

The Empirical Model

The following equation was used for estimating the rent gradient:

$$\log(Asvt_{ij}) = y_j\beta_y + HCBD_i\beta_{HCBD} + HCBD_i^{\,2}\beta_{HCBD^2} + NRST_i\beta_{NRST} + Ltsza\beta_{Ltsza} + Hszh\beta_{Hszh} + u_{ij}$$

Where *Lasvt* is the assessed value of land and improvements in thousands of dollars, *HCBD*, *H2CBD* are travel time to the central business district and its square, *NRST* is travel time to the nearest subcenter, *Ltsza* is the lot size in acres, *Hszh* is the house size in hundreds of square feet and y_j is a vector of neighborhood characteristics. The equation was estimated using ordinary least squares.[1]

The combined effect of parameter estimates on travel time to the central business district and its square define the rent gradient generated by access to the central business district. Since the gradient is a result of the combined effect of these two variables no expectation exists for either variable independently. Instead the combined effect is expected to be negative, suggesting that housing prices are a declining function of travel time to the city center. Similarly, the parameter estimate on travel time to the nearest subcenter defines the rent gradient generated by subcenters. Since this variable alone generates the gradient for subcenters, its expected sign is negative.

Housing prices are expected to be increasing in both house and lot sizes. Lot size and house size are both included in the empirical models to remove these effects and are therefore both expected to have positive parameter estimates.

Percent of the neighborhood that are nonwhite minorities, as well as the average house age and average number of rooms in houses in the neighborhood are included as neighborhood characteristics. Urban theorists have long considered the presence of minorities to decrease house values; that variable is therefore expected to have a negative parameter estimate. Older neighborhoods are also thought to have lower housing values, so that variable is expected to have a negative parameter estimate, as well. Larger houses are thought to increase the value of all houses in the neighborhood, so that variable is expected to have a positive parameter estimate.

The Results

Full results of the rent gradient appear in Table 8B below. Interpretation of the results are again complicated by the dependent variable being the log of the assessed value. To aid in the interpretation, for each regressor the price change attributable to a

[1] Tests of functional form supported the semi-log form used and the inclusion of the square of the distance to the central business district in the model. Tests of stability of the variance, with respect to distance to the central business district showed heteroskedasticity. Asymptotically consistent estimates of the variances of the parameter estimates are therefore reported and used for all tests. The results of a battery of misspecification tests are reported in Appendix 8B.

change in the regressor is calculated based on the estimated parameter holding all other regressors constant at their means. In the case of the two travel time variables – travel time to the central business district and travel time to the nearest subcenter- the change is based on a change of location to a location one-quarter hour further from the center or subcenter. For the other variables the change is based on an increase of one standard deviation from the mean. The findings with respect to each variable will be discussed in the order in which they appear in Table 8.2.

Table 8.2 The Estimated Rent Gradient

Variable	***Parameter Estimate***	***Price Change*** *(in dollars)*
Intercept	5.974* (.289)	
Access Variables (price change from increase of travel time by one-quarter hour from the mean)		
Travel time to the Central Business District	-3.390* (.533)	52,046
Travel time to the Central Business District squared	1.686* (.306)	
Travel time to the Nearest Subcenter	-0.524* (.049)	16,192
House Variables (price change by increase of one unit from the mean)		
House Size (in hundreds of square feet)	0.035* (.002)	5,407
Lot Size (in acres)	0.132* (.020)	21,621
Neighborhood Variables (price change by increase of one standard deviation)		
Percent Nonwhite Minority	-0.438* (.065)	-15,769
Average House Age	-0.003* (.001)	-4,823
Average Number of Rooms	0.069* (.012)	13,614
Observations	723	
Durbin Watson	1.898	
F-Statistic	152.602	
Significance	.000	
R^2	.631	

The different signs on the parameter estimates on the travel time to the central business district and its square complicate their interpretation. The price change computation, however, shows that at the mean the influence of the negative parameter estimate on the linear term dominates, generating the expected decline in price with increased travel time to the central business district. Moving one-quarter hour further from the central business district is found to decrease the price of the mean home in excess of $50,000. Evidence of the increase of housing prices with access to subcenters is found in the significant, negative parameter estimate on the travel time to the nearest subcenter. The estimate on that variable suggests that the difference in housing price between the mean housing location and a location one-quarter hour further from the nearest subcenter is over $16,000. The influence of subcenters on housing price is clearly smaller than that of the central business district, but is still significant.

Considering the interaction of the three travel time variables simultaneously helps to gain a better understanding of the rent gradient in the study area. This is accomplished in a manner similar to the consideration of the influences of access to centers on travel time in Chapter 6 above. Figures 8A, 8B and 8C are mappings of the price for the mean house generated by the parameter estimates from the rent gradient model. The x-y plane in the figures should be looked at as a map of the study area – the Washington, D.C. metropolitan area. The central business district is at the center. Subcenters are located on the x-y plane using their locations relative to the central business district. Figure 6C and Table 6B, which show and describe the positions of the various subcenters relative to the central business district are helpful in interpreting the graph. Since gradient was estimated using only Maryland data, borders with Virginia and the District of Columbia were approximated so that only estimated housing prices in Maryland are included in the graph.[2]

[2] Virginia boundaries were approximated by the angle that the Potomac River follows to the north and to the south of the District of Columbia. The boundary with the District of Columbia was approximated by limiting the data to households in excess of the minimum travel time to the central business district in the Maryland sample used to estimate the rent gradient.

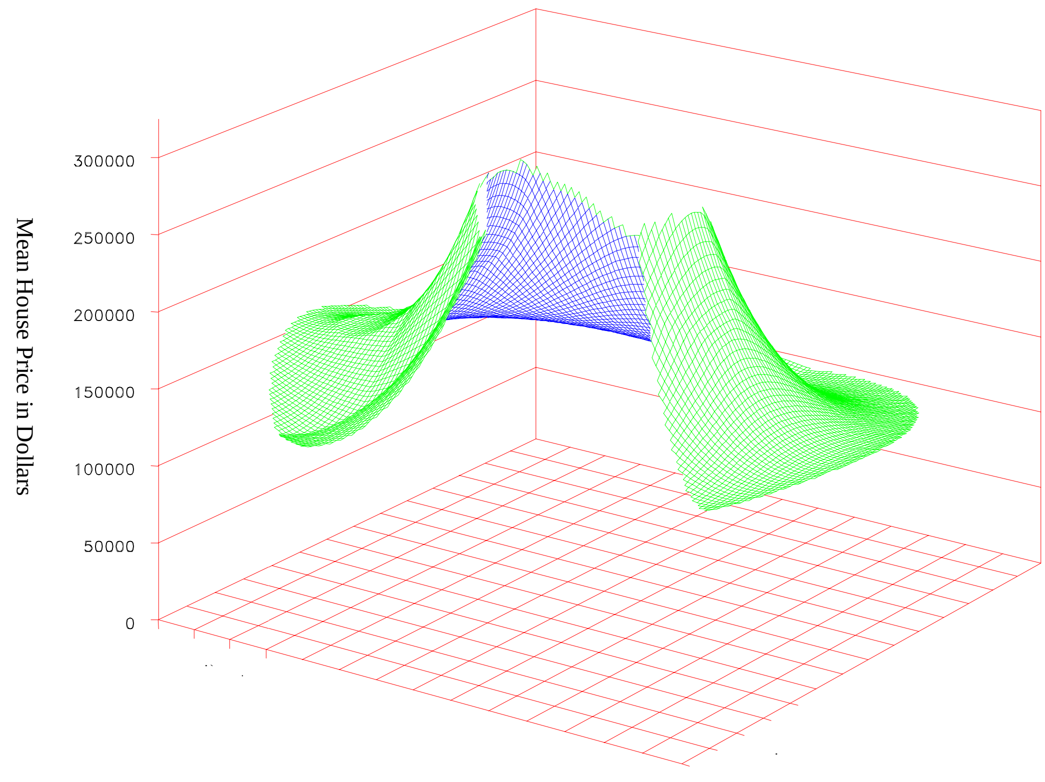

Figure 8A. Predicted House Prices (View 1)

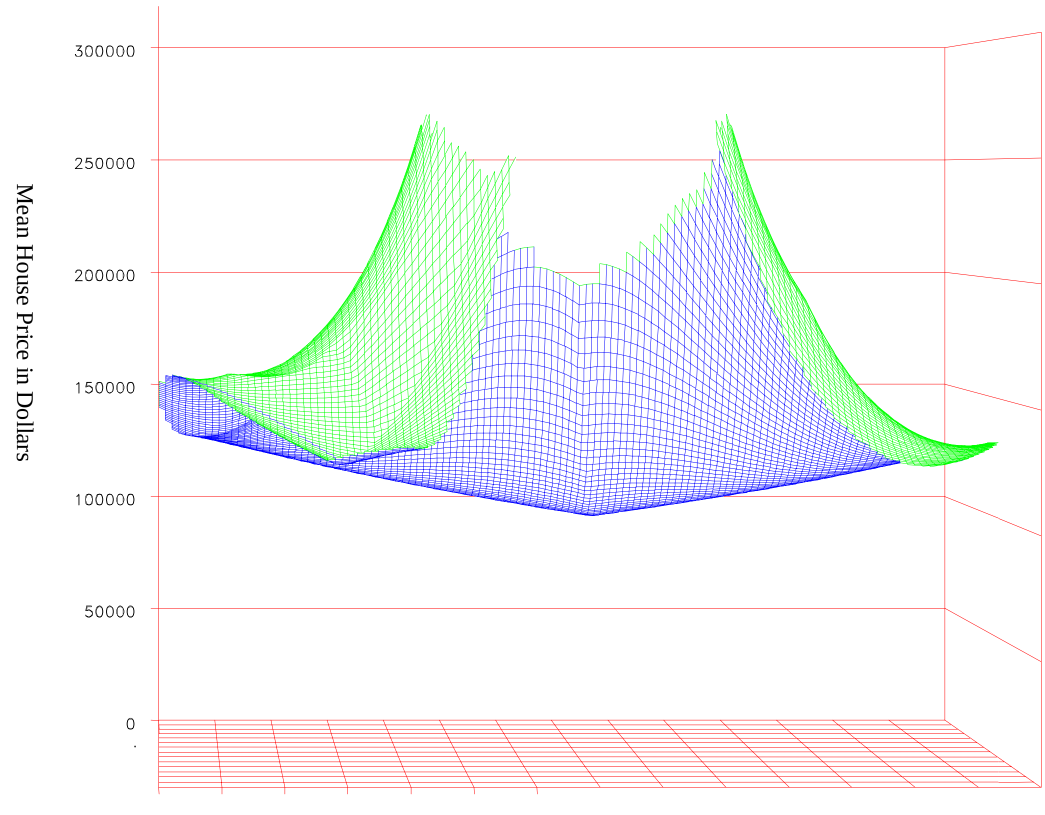

Figure 8B. Predicted House Prices (View 2)

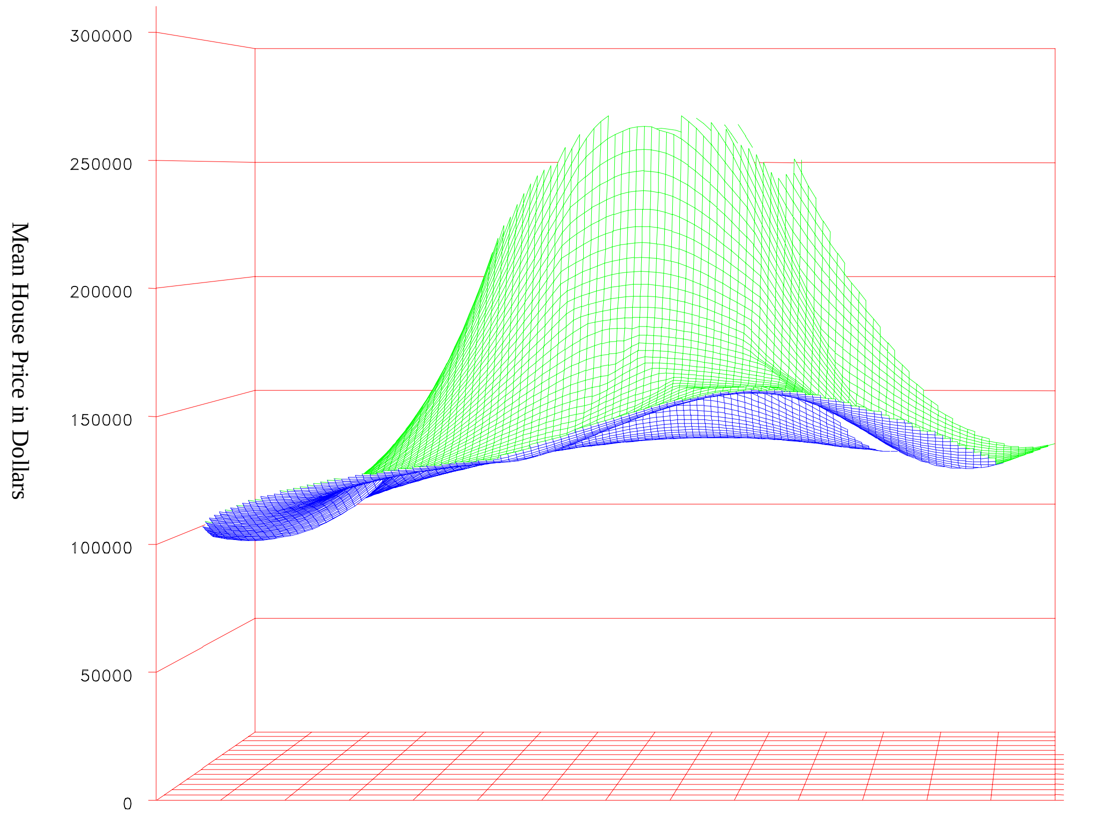

Figure 8C. Predicted House Prices (View 3)

Clear in the graphs is the fact that housing prices decrease sharply moving from the central business district. The highest estimated price, in the area closest to the central business district, exceeds $250,000. In the areas of the model most distant from the central business district the mean housing price falls below $100,000.

The influence of subcenters on housing prices is apparent throughout the graph. In the area to the extreme northwest of the central business district where several subcenters are found, the estimated mean house price is in excess of $150,000. To the east of the city, where no subcenters are found, the estimated price of the mean house is less than $100,000. Subcenter influence, however, is also observable in the areas closest to the central business district. To the northwest and southeast, areas with good subcenter accessibility, the estimated price for the mean house is over $50,000 greater than the price to the east, where subcenter access is poor.

The leveling at the edges of the graph suggest the edge of the gradient, where land is partially developed and some households have less connection to the metropolitan area. In these areas, one would expect to find a mixture of suburban residents commuting to jobs in the metropolitan area and households dependent on the rural economy.

The results, on the whole, suggest a polycentric rent gradient. Central business district access continues to have a significant influence on house prices. Subcenter access, while less significant, is also an important determinant of house prices. The parameter estimates for each of the other variables is significant with the expect sign. The results suggest the estimation, on the whole, is very robust. After discussing the results with respect to these other variables, the relationship between the earlier findings concerning household travel time will be reconsidered in light of the rent gradient estimated here.

House size and lot size parameter estimates both have the expected signs. Both parameter estimates, however, seem small in magnitude. An additional 100 square feet of house is estimated to increase the price of the mean house less than $6,000. An additional acre of lot is estimated to increase the price less than $22,000. The small magnitude of these estimates may be a result of interactions with the two travel time variables.

The results also suggest that neighborhood characteristics have a significant effect on house prices. The linear approximation using the parameter estimate on the nonwhite minority variable suggests that the price of the mean house will be decrease by $15,000 if the percent of minorities in the neighborhood increases from 30% to 50%. Lower house prices in older neighborhoods are suggested by the parameter estimate on the average house age. Lastly, the significant positive parameter estimate on the average number of rooms in houses in the neighborhood supports the conclusion that a house will bring a higher price in a neighborhood with larger (more expensive) houses.

The Rent Gradient and Household Travel Times

The results of the rent gradient estimation show that housing prices increase with improved access to the central business district and subcenters. The overriding question is whether these changes in housing prices are a reflection of household travel behaviors. Central place theory contends that housing prices are higher in locations that require less household travel. Figure 8D is a precursor to the in depth examination of this question in the next section. The figure shows the predicted household travel from the analysis of chapter 7 and the predicted housing prices of this section on the same graph. The graph uses the parameter estimates for both travel time to the central business district and travel time to the nearest subcenter. One subcenter is assumed by the graph, which is located slightly less than one-half hour from the central business district, the mean travel time to a subcenter from the central business district. The domains of the two graphs differ slightly since the domains of the two estimations differed slightly. In interpreting the graph, the slopes of the two lines are most pertinent. Comparing the slopes shows the relative differences in changes in household travel time and changes in housing prices, with travel time to the central business district and the subcenter.

As is apparent by the slopes of the two graphs, household travel times change less rapidly when housing prices with travel time to the central business district. The difference between changes in household travel times and changes in housing prices with distance to the central business district is greatest in the area immediately surrounding the subcenter. In that area the slope of the graph of household travel times is very small, while the slope of the graph of housing prices is largely unaffected by the presence of the subcenter.

The height of both graphs change dramatically on the side of the central business district without the subcenter. Household travel times increase and housing prices decrease with increase in travel time to the subcenter. The graph suggests that the decrease in housing prices with increases in travel times to the central business district and the nearest subcenter are not fully compensated for by increases in household travel times, as predicted by monocentric and polycentric theory. The graph also suggests that the dispersal of economic activity to subcenters (and perhaps beyond) has the effect of reducing the time households spend in travel. The most thorough understanding of this issue must include discussion of all of the previous results. This discussion is undertaken in the next chapter.

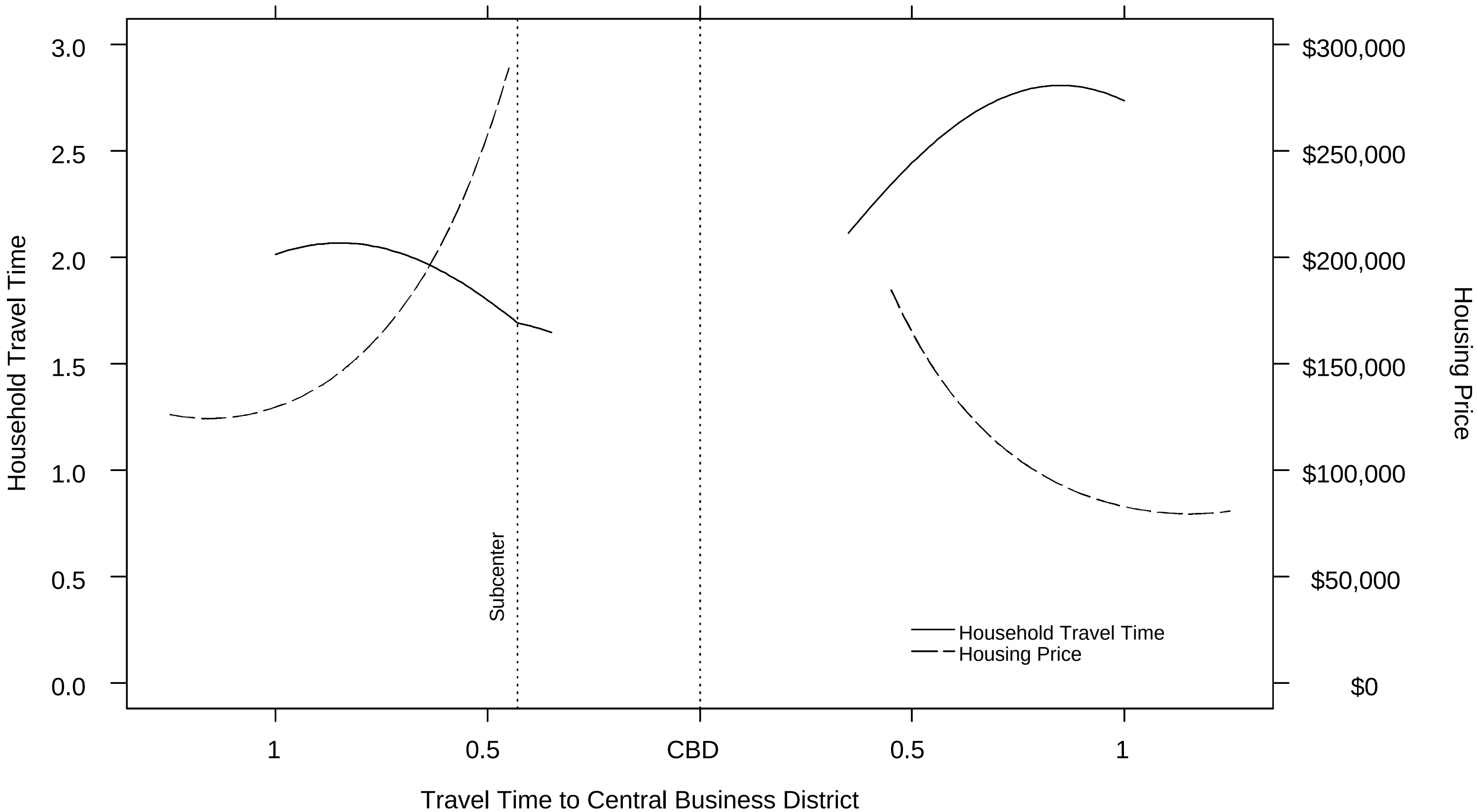

Figure 8D. Predicted Household Travel Times and Housing Prices as a Function of Travel Time (in hours) to the Central Business District and a Subcenter