Home Prices and Urban Corridors

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Abstract

This paper describes a semiparametric procedure to recover willingness to pay for housing and neighborhood attributes using a hedonic pricing model that incorporates spatial autocorrelation. To model taste heterogeneity, I estimate consumer preferences from parcel-level attributes in the form of household-specific random utility coefficients. The application here provides a way to reconcile home prices with the synergy created by the spatial dependence of residential homes and urban corridors. Specifically, the respective accessibility and nuisance effects of a commercial, an industrial/ transportation, a recreational corridor, and a highway, in Minneapolis are estimated. Ultimately, this paper addresses the question of how different types of households value different local economic development and housing attributes.

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INTRODUCTION

The cliché “Location. Location. Location.” is more than just a good starting point for discussing the housing market among real estate agents and their clients. For urban and transportation planners, and economists, such an expression has become fundamental in researching the interactions between land use, transportation, housing, population, and employment. From a household demand standpoint, construction of residential properties and zoning of land use affect travel behavior, transit corridors create amenity and nuisance effects for nearby households, and housing prices and affordability affect population that in turn generate jobs opportunities as a result of demand for goods and services. Ultimately, these reciprocal relationships are manifested spatially, so that they all play a key role in addressing the question of how different neighborhoods spur different local economic development and command different housing premiums.

One way to reconcile home prices with the synergy created by the spatial dependence of local economic activities, is by understanding the impact of urban corridors. In particular, the most relevant urban land development and infrastructures here are the highway, recreational, commercial, industrial, and public transit corridors. This is because a household's willingness to pay (WTP) for a home with certain attributes and for its location, can be inferred from their desire and ability to substitute between work and leisure. This concept is similar to that of the monocentric city model from urban economics, in which home prices and land use densities are derived as functions of proximity to downtown or to the central business district (CBD). Essentially, such framework shows how employment, land use, and housing are allocated in an urban setting. When this is extended to include the mobility of households through identifying and estimating the accessibility and nuisance effects of various urban corridors, the endogeneity in home prices arising from any spatial externality can be better explained.

The mechanism I investigate here connects home prices and household references for housing and neighborhood attributes, highlighting the critical roles of their spatial mobility. The primary approach used here is derived from the traditional hedonic pricing model for consumer demand, generalized to capture spatial externality. In such a model for housing demand, housing supply is fixed and each consumer is characterized by a utility function that depends on his preferences for various housing and neighborhood attributes. WTP is estimated through the consumer utility maximization problem and a pricing function based on residential property sales. Through the pricing function, a set of marginal willingness to pay (MWTP) measurements under the housing market equilibrium for observable housing characteristics are recovered (this is the reason for such function also being referred to a hedonic pricing function), so that household preferences in terms of their implicit WTP can be inferred. In order to capture the accessibility and nuisance effects of the various urban corridors, their respective distances to each home enter the pricing function exogenously, in addition to the set of attributes that characterizes the home.

To capitalize the effect of any spatial spillover of a property that may arise from the aggregation of contiguous spatial units and/ or the real estate appraisal process, weighted comparable sales of neighboring homes enter the pricing function endogenously. Implicitly, this means that the price of a home also depends upon the characterizing attributes of properties that have been recently sold. The resulting specification of the pricing function allows for heterogeneity in the curvature of preference functions. But there is more than merely recovering hedonic prices for observable housing and neighborhood characteristics. There exists housing and neighborhood attributes that are observed by households, but not by the econometrician. For any given residential property, only the household observe the view and quality of the home, and the surrounding households' demographics and economic conditions. By definition, unobserved attributes are product characteristics that are only known to the consumers. So in the context of residential properties, there must be some form of spatial correlations and differences that are also only observed by the households. Consequently it is only natural to extend the traditional hedonic pricing estimation for demand to include spatial externality and unobserved aspects of housing.

By recovering any omitted and unmeasurable housing characteristics, accounting for spatial dependency, the data can be better understood since the endogeneity in home prices arising from the error structure of the model is better identified.

In addition to estimating the accessibility and nuisance effects of various urban corridors and accounting for the spatial autocorrelation of comparable sales, I also analyze WTP as functions of several neighborhood socioeconomic aspects so that consumer taste parameters in terms of neighborhood demographics can be evaluated. The data set used here includes Minneapolis parcels sold between 1995-2007 from the Minneapolis City Assessor Office. Figure 1[1] describes the geographical location of the parcels with their associating land use composition[2] and of the urban corridors analyzed in this study. The corresponding structural data is available from Metropolitan Council and any missing structural data is purchased from Multiple Listing Service (MLS) by Transitway Impacts Research Program of the Center for Transportation Studies at the University of Minnesota. These three data sets are joined in ArcMap 9.2 (ESRI) for spatial references in terms of xy coordinates and Euclidean distance measurements[3]. Lastly, Census 2000 block group level data form MetroGIS DataFinder is spatially joined to the parcel data using GIS.

This study area surrounding the corridors of interest here is unique in several ways. First, this area a cul-de-sac in a sense that it is bounded by downtown Minneapolis and the University of Minnesota on the north side, and by the Mississippi River, the Minneapolis/ St. Paul International Airport, and the Fort Snelling national cemetery on the south. As a result, housing turnover in this area is relatively stable compared to the industrial based Northeast Minneapolis and other communities that are in close proximity to the Chain of Lakes. Second, the city of Minneapolis has been planning and recently started implementing major reconstructions and streetscaping on Lake Street, a major commercial corridor. Since these projects are estimated to cost around $30 million, the state and county officials anticipate a return on the city's investment based primarily on higher business sales tax as well as property tax revenues generated through these community revitalization projects. Therefore, the estimates from this study may provide a foundation for understanding and evaluating the impact of relevant regional urban planning policy. Lastly, the study area encompasses the newly opened light rail transit line that costs over $700 million in construction along the industrial corridor. This means that, based on the same reasoning as above, the findings here adds to the limited literature regarding the impact of the first modern transit infrastructure in Minneapolis on residential properties and other local economic development.

Empirically, the results of this study connect to research areas in hedonic pricing model and spatial econometrics. The extension here is the incorporation of spatial autocorrelation in the hedonic model for consumer demand under unobserved product heterogeneity, ultimately to recover household's WTP for any spatial externalities generated by urban corridors. The resulting preferences over spatial differences generate adjacency as well as neighborhood variations in housing demand, beyond many existing literature that only consider an employment corridor. As discussed earlier, urban corridors provide the critical link to studying and understanding households' preferences for certain housing and neighborhood attributes. Therefore the study here may have implications on how urban planning and local economic development have affected home prices and neighborhood heterogeneity in the United States.

The rest of the paper proceeds as follows. The next section introduces some of the recent work on the hedonic pricing model for consumer demand and for housing characteristics. Section 3 describes the model formulation for the pricing function and the underlying preference structure. This section also presents the data as well as the econometric estimators used following the identification and specification from the prior section. Section 4 summarizes the results and Section 5 concludes.

RELATED LITERATURE

Similar to the well-established hedonic pricing literature for consumer demand (Griliches (1961), Rosen (1974), Bartik (1987), Epple (1987)), this paper provides estimates for implicit prices for housing and neighborhood attributes. There are many recent studies that have improved upon the much criticized pricing model because of the issues of simultaneity and identification. Following some of the semiparametric approaches for random coefficients model (Berry et al. (1995), Berry (1994), Petrin (2002), Nevo (2001) and many others in the applied industrial organization literature), Bajari and Benkard (2005a) generalize Rosen's two-step approach to account for unobserved product characteristics under any form competition by omitting any restrictions on aggregate distribution of consumer preferences. They also relax the assumption of continuum of products by including the case of discrete product space. In terms of identification of the price function, they proof the existence of a bijection from the vector of product characteristics to prices, under three different assumptions for unobserved product attribute.

There are many others who consider this semiparametric style to account for preference heterogeneity and unobservable attributes (see Bajari and Kahn (2005), Bajari and Benkard (2005b), and Bajari and Kahn (2008)). In particular, Salvi (2007) derives demand for housing attributes in the Greater Zurich area and recover the MWTP for proximity to CBD. The key difference between current hedonic pricing literature and this study, although complementary, is that this paper takes spatial correlation into account by exploiting neighborhood comparable home sales. In terms of estimation, this added element of the model provides another dimension for generating endogeneity in home prices.

Several authors have studies spatial externalities and related issues with home prices. Following from the seminal work of Anselin (1988), Anselin (2002) revisits the assumptions, constraints, and implications from using regression models involving spatial lag (LAG) and spatial autoregressive residual (SAR). The LAG specification allows for comparisons of spatially lagged values of the dependent variables, while SAR involves adjusting errors that arise from inadequacies in geographical differentiation measurements. In application, Can and Megbolugbe (1997) develop a spatial hedonic model to capture the spillover effect of home sales by introducing a SAR term as an explanatory variable. In this manner the prices of the most recent sales of similar properties are considered in estimating the market value of a property, controlling for differences in their structural attributes and neighborhood characteristics. Comparing the SAR result to traditional hedonic regression, they find that the explanatory power of the model increases by at least 14% in terms of R-Square (R^2). Haider and Miller (2000) apply above SAR technique in their analysis, but they first use Moran's I autocorrelation statistics to detect existence of spatial autocorrelation by following the techniques outlined by Can (1992). In the end, they find that the SAR model improves the non-spatial model by about 5.3%, based on comparisons of adjusted R^2.

In order to recover household demand for air quality, Beron et al. (2004) investigate the issues involve in estimating housing prices with spatial spillovers. Using year dummies and their interactions with census demographics variables as instruments, they compare estimates from ordinary least squares (OLS) and SAR and conclude that SAR performs 2 -16% better than OLS. However, even with such improvements in R^2, the errors from their models account for at least 60% of the variations in households' MWTP. Many authors attribute such lack of explanatory power of the model to measurement error of the data, without any further investigation on its source. Therefore it is important to note that even with the increasing popularity of spatial regression techniques, addressing the simultaneity problem associated the lagged dependent variable and accounting for the unobserved aspects of housing should also be rudimentary in understanding home price data.

The work here also connects to the literature of sorting equilibrium in application to studying the relationship among home prices, housing attributes, and other socioeconomic factors. Ortalo-Magne and Rady (2008) incorporate income mixing, moving time, and tenure choice in their dynamic stochastic model to draw inferences on households' WTP for neighborhood attributes. Bayer et al. (2005) study the impact of income inequality on housing market equilibrium based on estimates recovered from estimating demand from household's income, race, education, and family structure. Using the same research strategy, Bayer and Ross (2008) estimate the effect of individual and neighborhood characteristics for labor market outcomes. Empirically, we all attempt to address the research question of how different neighborhoods command different housing premiums. The key value-added of the work here is the application to urban corridor using hedonic pricing model with spatial econometrics techniques accounting for unobserved product characteristics.

THE MODEL

The following section describes how a hedonic pricing approach is used to analyze the relationship between the housing market and consumer preferences. In the traditional hedonic pricing framework for consumer demand, there are two stages of identification and estimation. The first involve estimating consumer's MWTP for specific product characteristics, through regressing product price on the associated product characteristics. Following Bajari and Benkard (2005a), I assume that the unobserved product characteristics are independent of the observed product characteristics.

There is a fixed supply of housing products and households in this setting trade without any transaction costs. Let all households have monotone preferences in all characterizing attributes and put the resulting utility representation of each household $i \in I$ to be u_i. Assuming that each household derives utility from consuming a numeraire good $c \in R^+$, a housing product $j \in J$ with a set of *K* observed housing attributes $x_j \in R_+^K$ such that $x_{jk} \in R^K$, for all *k* and *j*, as well as a scalar of unobserved idiosyncratic household specific characteristics $\xi_i \in R$, then we write

$$u_{ij} = u_i(c, \mathbf{x}_j; \xi_j) \tag{3.1}$$

Taking household income E_i, the set hedonic pricing function $p_j = p(x_j; \xi_j)$, for all *j* that map all housing attributes of one type housing unit into prices, and the price for the numeraire commodity as given, each household solves the following problem

$$\max_{c,j} u_i(c, \mathbf{x}_j; \xi_j) \quad \text{s.t.} p_j + c \leq E_i \tag{3.2}$$

Assuming interior solution to above maximization problem and that both u_i and p_i are twice continuously differentiable functions, the first order conditions for above maximization problem for all household *i* are

$$\frac{\partial u_{ij}}{\partial x_{jk}} = \frac{\partial p_j}{\partial x_{jk}} \frac{\partial u_{ij}}{\partial c} \tag{3.3}$$

$$\frac{\partial u_{ij}}{\partial \xi_j} = \frac{\partial p_j}{\partial \xi_j} \frac{\partial u_{ij}}{\partial c} \quad \forall\ j = 1, \ldots, J,\ k = 1, \ldots, K \tag{3.4}$$

so that at the chosen bundle of goods, the rate at which a housing attribute is traded for the numeraire must equal the marginal rate of substitution between the two. Assuming that utility u is linear in the composite good c, the second order conditions are

$$\frac{\partial^2 u_{ij}}{\partial x_{jk}^2} - \frac{\partial^2 p_j}{\partial x_{jk}^2} < 0 \tag{3.5}$$

$$\frac{\partial^2 u_{ij}}{\partial \xi_j^2} - \frac{\partial^2 p_j}{\partial \xi_j^2} < 0 \tag{3.6}$$

and together with the Implicit Function Theorem for a unique solution, there exists functions $x_{jk} = x_{jk}^*(c, x_j; \xi_j)$ and $\xi_j = \xi_j^*(c, x_j)$ for all attributes k and products j such that (3.3) and (3.4) can be rewritten as

$$\left.\frac{\partial u_{ij}}{\partial x_{jk}} = \frac{\partial p_j}{\partial x_{jk}}\right|_{x_{jk}=x_{jk}^*(c,\mathbf{x}_j^*;\xi_j^*),\ \xi_j=\xi_j^*(c,\mathbf{x}_j^*)}$$

$$\Rightarrow u_{x_k}(c, \mathbf{x}_{jk}^*, \xi^*) = p_{x_k}(\mathbf{x}_{jk}^*, \xi^*) \tag{3.7}$$

and

$$\left.\frac{\partial u_{ij}}{\partial \xi_j} = \frac{\partial p_j}{\partial \xi_j}\right|_{x_{jk}=x_{jk}^*(c,\mathbf{x}_j^*;\xi_j^*),\ \xi_j=\xi_j^*(c,\mathbf{x}_j^*)}$$

$$\Rightarrow u_\xi(c, \mathbf{x}_{jk}^*, \xi^*) = p_\xi(\mathbf{x}_{jk}^*, \xi^*) \tag{3.8}$$

Taking partial derivative of (3.7) with respect to ξ, we have that

$$\frac{\partial x_{jk}^*}{\partial \xi} = \frac{p_{x_k\xi} - u_{x_k\xi}}{u_{x_kx_k} - p_{x_kx_k}} \tag{3.9}$$

so that $\frac{\partial x_{jk}^*}{\partial \xi_j}$, the changes to an observed housing characteristic given a change in the unobserved attribute, is an increasing function if and only if $p_{xk} < u_{xk}$. This means that when an unobserved attribute, adds to the marginal utility of a particular attribute more than its marginal cost, the demand of the attribute increases.

Accounting for taste in each household's utility, we can rewrite (3.1) as

$$u_i(c, x_j; \xi_j) = \beta_{i,x_{j1}} ln\ x_{j1} + \cdots + \beta_{i,x_{jK}} ln\ x_{jK} + \beta_{i,\xi_j}\ ln\ \xi_j + c \tag{3.10}$$

where $\beta = (\beta_{i,x_{ji}}, \ldots \beta_{i,x_{jK}}, \beta_{i,\xi_i})$ is the set of random taste coefficient that represent household *i*'s preferences for all observed and unobserved attributes from choosing housing type *j*. Now we can rewrite (3.3) and (3.4) as

$$\beta_{i,x_{jk}} = x_{ijk}\frac{\partial p_j}{\partial x_{ijk}} \tag{3.11}$$

$$\beta_{i,\xi_j} = \xi_{i,j}\frac{\partial p_j}{\partial \xi_{i,j}} \quad \forall\ j = 1, \ldots, J,\ k = 1, \ldots, K \tag{3.12}$$

in order to recover the vector of household *i*'s preference parameters involved in choosing housing product *j*, given that we know each household's pricing function p_j and unobserved characteristics ξ_i. Aggregating all households, we can then recover the population distribution of each preference coefficient. In particular, the empirical counterpart of such cumulative distribution function is

$$\hat{G}_\beta = \frac{1}{I}\sum_i^I 1_{[\hat{\beta}<b]} \tag{3.13}$$

where $1_{[\cdot]}$ denotes the indicator function.

In terms of the pricing function, it is formulated to recover the unobserved product characteristic, accounting for spatial autocorrelation. This involves regressing home prices on spatially lagged home prices, as well as on the set of observed and unobserved housing attributes. Specifically, pick a housing type *j* with the associating p_{ji} and attributes (x_{jik}, ξ_{ji}). The formulation for adding a spatially autoregressive term into the traditional hedonic pricing model is,

$$p_{ji} = \alpha_0 + \sum_k^K \alpha_k x_{jik} + \rho \sum_n^N w_n p_{jin} + \xi_{ji} \tag{3.14}$$

The parameter ρ in (3.14) measures the strength of spatial dependence between p_{ji} and all transaction prices $\{p_{jin}\}_n^N$ four months prior that are within a three-quarter miles radius[4]. The significance of prior sales is specified by weights ω_n, which are determined by the locations in which transactions $\{p_{jin}\}_n^N$ occurred. Assuming that the closer the other sales are in terms of proximity, the more influential they are on the sale in question. This type of spatial dependency is captured by

$$w_{jn} = \frac{1/d_n}{1/\sum_n^N d_n} \tag{3.15}$$

and it defines a multidimensional distance-decay/ lag matrix. Furthermore, the residual of regression equation (3.14) is precisely the unobserved housing characteristic. In matrix notation, we have

$$\mathbf{p} = \mathbf{x}\boldsymbol{\alpha} + \rho\mathbf{W}\mathbf{p} + \boldsymbol{\xi} \tag{3.16}$$

so that the estimations for (3.7) and (3.8) reduce to

$$\hat{\beta}_{i,x_{j,k}} \equiv \hat{\beta}_{x_{i,.k}} = x_{i,k}\left([I-\rho W]^{-1}\right)_{i,k}\hat{\alpha}_{i,k} \quad \forall\ j = 1,\ldots,J \tag{3.17}$$

$$\hat{\beta}_{i,\xi_j} \equiv \hat{\beta}_{\xi_{i,j}} = \hat{\xi}_i\left([I-\rho W]^{-1}\right)_{i,j} \quad \forall\ i = 1,\ldots,I \tag{3.18}$$

These estimates yield household specific WTP for the observed and unobserved housing attributes. Note that they are functions of weighted inverse distance as well as the overall strength of spatial dependency of the type of residential home. The interpretation, as a result of using comparable sales, is that the marginal change in housing price from changes in one characteristic is composed of changes of all other characteristics of neighboring homes. For example, the effect of a change in distance to a light rail transit station on home *i* is the sum of the direct effect on the property and of the indirect effect of nearby properties.

The second stage of estimation involves recovering household WTP as well as demand for each product. Recall from the specification of the utility function, the set of random taste coefficients are household specific. These measure the WTP for the each product attributes (the exogenous variables in the pricing function 3.16) as they are the product of the quantity of the attributes and their associating MWTP, where MWTP is simply the derivative of the pricing function with respect of the attribute.

To see how these taste coefficients behave as functions of socioeconomic factors, I specify the regression:

$$\boldsymbol{\beta}_{\mathbf{x}_{jg}} = \mathbf{d}_{jg} \cdot \boldsymbol{\theta}_{jg} + \boldsymbol{\eta}_{jg} \tag{3.19}$$

where $d \in R_+^S$ is the set of S socioeconomic attributes, with resolution usually not available at the parcel level. Instead of i, the subscript g is used to denote census tracts or block groups. θ is the set of regression coefficients and η is the error term with mean zero and independent from any socioeconomic factors. Due to aggregation, the functional form of this regression is linear in its regressors. Also involved in this stage is recovering the implicit demand functions for each product. This is essentially computing

$$q_j(p_1, \ldots, p_J) = \sum_i^I 1_{[u_{ij} > u_{il}\ \forall\ l \neq j]} \tag{3.20}$$

with estimates for all unknown components of u_{ij} computed from the first stage.

Given above assumptions, formulations, and the optimality conditions of the household utility maximization problem, I formalize the necessary estimations involved in the next section.

METHODS & PROCEDURES

For the first stage of estimation, a linear regression on the housing pricing function is used. The set of housing products J are the types of structures among the markets for single-family homes and multifamily homes. In particular, I focus on properties that are surrounded by and are within a half mile radius of these corridors to filter out the effects of nearby lakes and the Mississippi River. Figure 2[5] is a map of Minneapolis, highlighting the relevance of each urban corridor along different neighborhoods of the city. Within the study area of South Minneapolis, there is an eight-lane highway, Interstate 35W[6], on the west side, a commercial corridor, Lake Street[7], on the north, an industrial/ transportation corridor, Hiawatha 55[8], on the east, and a recreational corridor, Minnehaha Parkway10, on the south. In capturing the accessibility of the urban corridors, distance from each home to the nearest freeway on/ off-ramp and major traffic intersection are measured in GIS. Similarly, the nuisance effect (if applicable) is approximated by each home's shortest distance to each corridor. Since there is no reason to expect the recreational corridor to have any negative externality, I do not estimate a nuisance effect for this corridor. Its accessibility effect on the other hand, is measured the same way as the nuisance effects of the other corridors.

In terms of the bundle of housing characteristics x_i that enters into household's utility and are available from data, I have:

- $YR\ BLT_i$: The year built of home *i*.
- $LOT\ SIZE_i$: The size of the lot of which home *i* is located in terms of square footage.
- $GROSS\ BUIL_i$: The total building area of home *i* in terms of square footage.
- $TOTAL\ BEDR_i$: The total number of bedrooms in home *i*.
- $TOTAL\ BATH_i$: The total number of bathrooms in home *i*.
- $DIST\ TO\ CBD_i$: The distance to downtown Minneapolis (7th Street and Nicollet Avenue) from home *i*.
- $DIST\ TO\ ST_i$: The distance to nearest LRT station/ major traffic intersection of Hiawatha 55 from home *i*[9].
- $DIST\ TO\ TRACK_i$: The shortest distance to LRT track/ Hiawatha 55 from home *i*.
- $DIST\ TO\ 35W_i$: The shortest distance to Interstate 35W from home *i*.

- $DIST\ TO\ 35WOO_i$: The distance to nearest Interstate 35W on/ off-ramp from home *i*.
- $DIST\ TO\ PARK_i$: The shortest distance to Minnehaha Parkway from home *i*.
- $DIST\ TO\ LAKE_i$: The shortest distance to Lake Street from home *i*.
- $DIST\ TO\ LAKEI_i$: The distance to nearest traffic intersection of Lake Street from home *i*.

For the second stage of estimation, WTP for urban corridors for single-family as well as multifamily homes are estimated. Using the estimated WTP, each taste coefficients are regressed on the following set of Census 2000 block group level demographics variables:

- $GRADCOL_g$: The percentage of population 25 years and over with bachelor's degree or higher in group *g*.
- $HSE\ PCT_g$: The percentage of homeownership in group *g*.
- $IHMED_g$ IHMEDg: The medium household income in group *g*.
- PCT_g : The percentage of Hispanic, Latino, and African Americans in group *g*.

Essentially above variables are demand shifters, so that implicitly the specification here yields how households' WTP for each urban corridor differ with different socioeconomic characteristics in different Census block groups. In aggregation, I take averages of taste coefficients and demographic variables based on random enumeration of households within the study area following Bajari and Kahn (2008), in order to generate enough covariates within the estimations. The set of linear regressions to be estimated are

$$\begin{aligned} \bar{\boldsymbol{\beta}}_g &= \boldsymbol{\theta}_{0g} + \boldsymbol{\theta}_{1g}\overline{GRADCOL}_g + \boldsymbol{\theta}_{2g}\overline{HSE\ PCT}_g \\ &\quad + \boldsymbol{\theta}_{3g}\overline{IHMED}_g + \boldsymbol{\theta}_{4g}\overline{PCT\ B}_g + \boldsymbol{\theta}_{5g}\overline{PCT\ H}_g + \boldsymbol{\eta}_g \\ E[\boldsymbol{\eta}&|\overline{GRADCOL}_g,\ \overline{HSE\ PCT}_g,\ \overline{IHMED}_g,\ \overline{PCT\ B}_g,\ \overline{PCT\ H}_g] = 0 \end{aligned} \tag{3.21}$$

As for recovering demand for each type of homes, the estimated utility level (obtained by substituting into the vector of β and ξ) of all households are compared, as outlined by equation (3.20). That is, for housing type *j* to be chosen over *l* and that the budget constraint of the household is binding, it must be that,

$$\begin{aligned} & \hat{u}_i(E_i - p_j, x_j; \xi_j) \geq \hat{u}_i(E_i - p_l, x_l; \xi_l) \\ \iff\quad & \hat{\beta}_{i,x_{j1}} ln\ x_{j1} + \cdots + \hat{\beta}_{i,x_{jK}} ln\ x_{jK} + \hat{\beta}_{i,\xi_j}\ ln\ \hat{\xi}_j - p_j \\ & \geq \hat{\beta}_{i,x_{j1}} ln\ x_{l1} + \cdots + \hat{\beta}_{i,x_{jK}} ln\ x_{lK} + \hat{\beta}_{i,\xi_j}\ ln\ \hat{\xi}_l - p_l \end{aligned} \tag{3.22}$$

for preferences identified up to a monotone transformation in ξ (refer to Matzkin (2003) and Heckman et al. (2005) for the establishment identification results).

RESULTS

It is natural to anticipate that the impacts of the various urban corridors affect the pricing of single-family and multifamily homes differently. Due to zoning (and therefore land use), transportation infrastructure, and neighborhood demographics, there are two separate markets for these two types of residential properties. In particular in the market for multifamily homes, there are differentiable types of properties that can be viewed as different products. Consequently, the estimated WTP for the different housing attributes, and the accessibility and nuisance effects of each of the urban corridors should vary noticeably among the two types of homes. Table 1 report the averages of the housing structure of the respective groups of data used in this study. Multifamily homes in this area are on average larger in terms of gross building size, mainly because they usually include common areas, laundry facilities and parking lots. Also, these properties have more bedrooms and bathrooms on average, possibly because residents in a multifamily home are less likely to share living areas. In terms of proximity to the respective urban corridors, note that single-family homes on average are slightly further away from the highway as well as the commercial corridor, while being much closer to the recreational corridor.

Table 1: Means of Single-family and Multifamily Housing Attributes.

	SFH		**MFH**	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
sale_val	143917.9	62002.7	151628.4	70470.38
yr_blt	1923.096	16.58689	1916.418	22.44165
lot_size	5487.643	1409.614	5350.086	1544.397
gross_buil	1247.925	398.0547	2061.374	607.8152
total_bedr	2.790834	0.8673423	4.044406	1.37889
total_bath	1.513333	0.6829691	2.213757	0.5498041
dist_to_cbd	5991.137	1351.927	4718.824	1434.11
dist_to_st	2185.005	1340.035	2102.55	1145.312
dist_to_track	2089.026	1400.897	2000.678	1203.595
dist_to_35w	577.5967	438.0724	424.0738	347.8865
dist_to_35woo	617.8814	415.235	478.8687	315.0068
dist_to_park	467.9919	334.3779	793.2736	377.4718
dist_to_lake	736.5922	388.8934	423.3101	374.0449
dist_to_lakei	752.4796	386.3017	437.8465	371.8238

A drawback of this data set is the lack of sales and structural information of condominium homes in the study area. Given that there has been significant condominium development and transactions in the multifamily homes market between 2004-2006, excluding this data subset drastically affect the robustness of the estimation involving multifamily properties. Indeed, in a related study, Goetz et al. (2008) attribute the lack of fit of their model for multifamily homes to the exclusion of condominium data.

First Stage Estimates for Hedonic Pricing Function

Recall from equation (3.14) that the set of parameters to be estimated are $\alpha = (\alpha_{j,0}, \ldots, \alpha_{,K})$ and ρ. The inclusion of weighted comparable sales creates an endogeneity problem within the model, so that a Maximum Likelihood estimator is used here[10], with the additional assumption of normally distributed error term. Unlike the traditional hedonic pricing function, the estimates here are not MWTP because of the spatial autocorrelation term. Therefore I cannot infer how a typical household value an extra bedroom or a shorter walking distance to the park, merely from this first stage of regression. Table 2 displays the estimates for the respective pricing function for the two types of residential properties.

As reported in the table, all coefficients for the housing attributes have the anticipated signs and plausible magnitudes[11]. Indeed there exists significant spatial dependence between the price of a home and its comparable sales. Specifically, the spatial correlation between a typical single-family home and its neighbors is stronger than the correlation between a typical multifamily home and its neighbors. This could be the result of how comparable sales are examined in the real estate market. In practice, it is not unusual to compare and judge single-family properties merely based on visual inspections of the outside. On the other hand, the same cannot be done for multifamily properties that are located in multi-level buildings, no matter the experience of the real estate agent. Another contributing factor of the difference in the estimated spatial correlation is the higher number of comparable sales for single-family homes, due to the spatial nature of the data set (recall land use decomposition from Figure 1). Comparing the structural characteristics of

Table 2: Hedonic Price Regressions.

	SFH		MFH	
Variable	Coef.	Std. Err.	Coef.	Std. Err.
weights	0.8208637	0.0141455	0.4851892	0.0261822
yr_blt	234.7745	23.82756	352.0874	71.4932
lot_size	5.203376	0.2886691	4.198927	0.8884817
gross_buil	46.49853	1.41933	31.2715	2.798986
total_bedr	2620.413	564.871	5227.369	1172.894
total_bath	6444.926	663.9933	4593.714	2547.243
dist_to_cbd	-23.16296	2.502527	-15.85535	7.467334
dist_to_st	6.424201	3.476107	-1.990553	13.12175
dist_to_track	12.95208	3.51775	22.27762	13.00609
dist_to_35w	76.9078	8.862464	82.05436	22.96073
dist_to_35woo	12.84144	7.583703	-0.807732	17.11313
dist_to_park	-50.18703	3.958613	-13.05858	17.40129
dist_to_lake	293.4394	31.07301	231.5779	90.07886
dist_to_lakei	-285.8558	32.50039	-190.9248	94.04303
constant	-459983.9	47358.34	-716365.9	144549.5
Number of obs	12263		2297	
Wald Chi(14)	17406.2		1186.88	
Prob > chi2	0		0	

the properties, newer homes with more number of bedrooms are more attractive to multifamily home buyers. Even though it is more likely for residents in a single-family home to share living space, they place higher value on additional bathrooms than those in a multifamily home.

From the results of single-family home properties, there are accessibility effects for proximity to downtown, as well as to the recreational corridor and the commercial corridor. Such effects can be inferred from the negative sign of the coefficient in question. As expected, there are nuisance effects for proximity to the industrial/ transportation, highway, and commercial corridors, based on the positive signs on the estimates. Naturally, this is the result of noise and traffic congestion. In particular, the unsightly view of grain elevators and freight rail train tracks along the industrial corridor can be overwhelming (this is consistent with the result found in Goetz et al. (2008)). As for the commercial corridor, demolitions of older buildings and road constructions are expected to continue in the next five years. Overall, the residents of this type of properties substitute between living in newer and larger homes with more living area and being further away from the CBD, as well as the commercial and recreational corridors.

The results for multifamily homes are also consistent with economic intuition on the types of externality that urban corridors can generate. One significant finding here is that there are accessibility effects for proximity to downtown and all the urban corridors. This means that the tradeoffs between housing and location amenities faced by this type of households are larger. In this case households are substituting between the amenities associated with their location and the structural aspects of their homes. The nuisance effect for proximity to the highway corridor remains strong in this case.

Second Stage Estimates for Preferences

Taste Coefficients for Urban Corridors. To compare household's taste preferences consistently, I calculate the WTP for a 10% increase in every housing attributes to standardize all units. Since there is no standard definition for WTP, I follow Bajari and Kahn (2005) to redefine WTP as the change in household utility, subject to a 10% change in a particular attribute, holding everything else constant. Again, the estimates here are household-specific, as a result of the spatial dependence in the model, which is captured by the distance-decay weight matrix. Table 3 displays the results for single-family home households in the study area. The most that this type of home buyers are willing to pay for is being away from the commercial corridor, even they highly value the access to major intersections of this busy street. As mentioned before, traffic and congestion along this corridor can overwhelm any of its proximity benefits and this is the reason for the resulting nuisance effect being slightly larger than its accessibility effect. Also noticeable here is the amount households that are willing to pay for proximity to the CBD. In fact, the value the average household places on being 10% closer to the CBD is higher than the values placed on 10% increases most other housing attributes. It turns out that on average, this type of household does not value proximity to any of the transportation corridors.

To understand how these taste coefficients correlate with one another, as well as to examine the types of tradeoffs that households are facing when choosing among different housing and location attributes, I compute the correlations among these variables. The findings (not reported here) for housing attributes are as expected: households who are willing to pay more for larger living area should also be willing to pay for more bedrooms and bathrooms. As explained earlier, this type of households substitutes between the size of their homes with proximity to the CBD and with the amenity effects of the commercial and recreational corridors. Also, households of this type are willing to pay for newer and larger homes, as long as they can avoid the freeway and the industrial/ transportation corridor. In terms of tastes, there are significant differences between multifamily households and single- family home households (refer to

Table 3: Household Willingness to Pay- Single-family Homes

Willingness to Pay Estimates

Single-family Homes

Variable	Mean	p25	p50	p75
yr_blt	212097.9	-39021.16	135442	247921.2
lot_size	12930.15	-2135.063	8585.646	15524.25
gross_buil	27775.32	-3715.091	18505.6	31308
total_bedr	3535.104	-420.3737	2273.839	3996.198
total_bath	6545.061	-646.8746	2940.685	5332.17
dist_to_cbd	-74361.85	-76025.08	-40884.62	10471.4
dist_to_st	7617.744	-659.7386	3167.034	7411.777
dist_to_track	14676.64	-936.5872	5524.778	14337.91
dist_to_35w	20039.09	-538.073	8583.655	26557.48
dist_to_35woo	3608.847	-225.3331	1743.895	4691.234
dist_to_park	-6267.404	-13040.35	-5073.988	858.0858
dist_to_lake	140666.6	-7488.418	56872.09	120011.2
dist_to_lakei	-138730.9	-119585	-56906.62	8328.568

Table 4).The value that multifamily homes households place on the amenity effects of various corridors is much smaller. This is a direct result of the lower spatial dependence among the pricing of multifamily homes. As explained earlier, the lower the degree of spatial correlation, the less the neighboring WTP is captured by the model. Consistent with the findings for the estimates of the pricing function, multifamily home households care more about the additions in the number of bedrooms than single-family home households, due to their difference in how much they are willing to share living space. Contrary to the previous case, this type of household's WTP for accessing the industrial/ transportation corridor is positive, although the magnitude is small. This can be attributed to the increasing number of new multifamily housing development in along Hiawatha 55 in recent years, noticeably apartment building complexes and condominium

In addition, the WTP estimates for proximity to various highway entrance and exits are positive. Given such preferences for these transportation corridors, multifamily home households are more mobile and accessing the freeway and the light rail line has a substantial part in their housing decisions.

Similar to the case of single-family homes, the correlations among WTP of multifamily home households for structural attributes are strong. However, the tradeoffs that they make among their relative location to various corridors are quite different. In particular, households WTP for accessing Hiawatha 55, 35W, and Lake Street, are inversely correlated to their WTP for the respective corridor's nuisance effects. This is also true for the correlation between WTP for accessing Minnehaha Parkway and WTP for avoiding any nuisance effects of the other corridors. Altogether, there are stronger correlations among all WTP among the various urban corridors, showing that the interconnectedness of amenity and nuisance effects of the study area has higher impact on the residents in multifamily homes than those in single-family homes.

Empirically I recover the distributions for the all taste coefficients β_i for all household *i*. Again, these coefficients measure households' WTP for the quantity of the attributes associated with their homes, accounting for both direct and indirect effects of the changes in the housing attributes due to spatial correlation. Keeping the goal of this study in mind, here I only present the results for the respective corridors. The following figures show the distributions of the random

Table 4: Household Willingness to Pay- Multifamily Homes

Willingness to Pay Estimates
Multifamily Homes

Variable	Mean	p25	p50	p75
yr_blt	168267.1	95988.37	117516.4	158614.5
lot_size	5877.025	3032.381	3971.724	5578.474
gross_buil	17087.82	8742.922	11417.73	15282.2
total_bedr	4998.26	2781.238	3656.252	5256.501
total_bath	2539.128	1383.146	1765.673	2434.558
dist_to_cbd	-18116.67	-19107.63	-13292.57	-9259.162
dist_to_st	-979.0059	-1193.325	-701.8886	-337.636
dist_to_track	10410.37	3028.252	7463.692	12955.08
dist_to_35w	8841.025	1746.19	4804.632	10337.21
dist_to_35woo	-98.23834	-108.3749	-59.06969	-30.0165
dist_to_park	-2659.802	-2726.854	-1881.411	-966.4884
dist_to_lake	21676.91	4866.052	12907.52	30404.99
dist_to_lakei	-18429.5	-25701.9	-11207.68	-4710.165

coefficients for proximity to the various urban corridors from each type of the households. Since the domains of theses coefficients vary drastically, their distributions are displayed within the 10th and the 90th percentile, in order to improve visual clarity.

Figure 3 and Figure 4 display the distributions of households' evaluation of proximity to the Interstate 35W. In particular, plotted on the right is the distribution for the nuisance effect while on the left is the distribution for the accessibility effect. The findings here support above WTP estimates. Only the lower 30 percentile of single-family households place positive value for accessing the highway's on/ off-ramps, while the is true for almost all multifamily households. This means that households in multifamily dwellings are much more dependent on automobile and that they place higher priority on shorter commute time. As explained before, the two types of households can be affected by traffic differently simply due to the nature of the type of the dwellings. In order to avoid the noise and the view of the highway, almost all multifamily households are willing to pay a positive amount, whereas this is not true for the first quartile of single-family households.

The patterns from the distributions of the commercial corridor resemble to those of the previous, possibly as a result of the architecture of residential structures that are being studied. According to Figure 5, almost all multifamily households value accessing major traffic intersections of the commercial corridor while avoiding the street's noise and traffic. In this case, single-family homes residents are less attracted to the small, independently owned retail shops and restaurants located along this corridor. In contrast, the top quartile of the single-family households (refer to Figure 6) does not value the accessibility effect of this corridor and the lower quartile of these families does not consider the corridor to be a nuisance.

The negative impact of the industrial/ transportation corridor is overwhelming in the case for single-family homes. Whether it is measured by distance to the nearest traffic intersections of Hiawatha 55/ LRT stations or distance to Hiawatha 55/ LRT track, the upper 70 percentile of

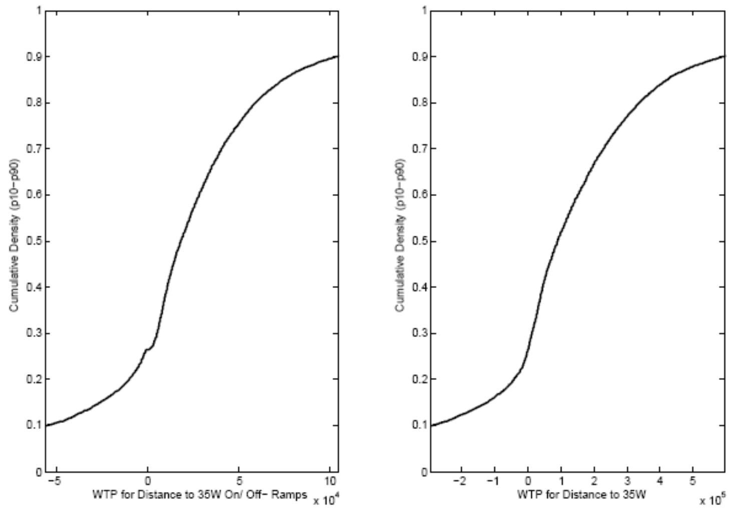

Figure 3: Willingness to Pay for Proximity to the Highway- Single-family Homes.

households of this type of homes are paying positive amounts to avoid this corridor altogether (refer to Figure 7). Indeed, in Goetz et al. (2008), the authors find that the opening of the LRT in

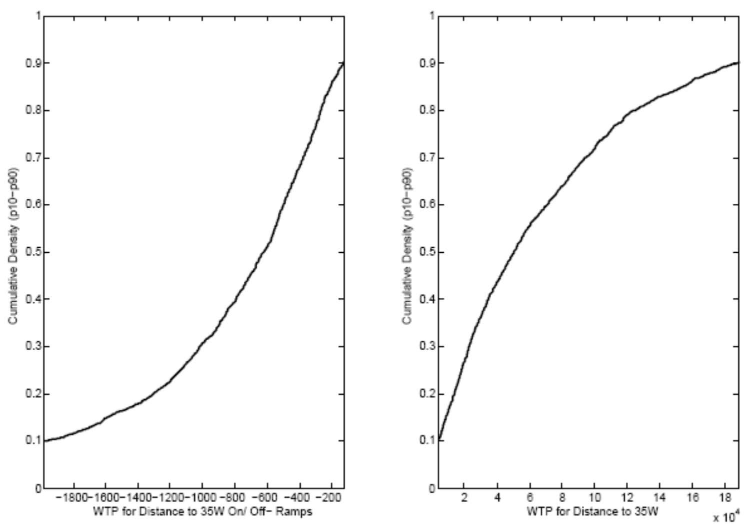

Figure 4: Willingness to Pay for Proximity to the Highway- Multifamily Homes.

line has only ameliorated some of the negative impact of the industrial corridor in the case of single-family homes. For multifamily homes, they find that the LRT line has created an accessibility effect for this type of properties, while adding to the negative impact of the corridor general. Such results are consistent with my findings. In Figure 8, almost all households in this case are paying positive amounts for the amenities of the corridor and for the distance away from its nuisance. The reasons behind these results are based on the mobility of the different types of households and the different types of structures of the homes, similar to those from the analysis for the highway corridor.

Since I assume that there is no nuisance effect generated by the recreational corridor, I do not measure such impact and the results presented here are only in terms of its accessibility effect. The results displayed in Figure 9 and Figure 10 are consistent with economic intuition that households derive utility from leisure: in both cases over 3 quartiles of households places positive amounts on their valuation of proximity to the park. Assuming that single-family home households are more likely to have children, they are more likely to care more about the amenities associated with this corridor. Accordingly, their valuations are in fact slightly larger

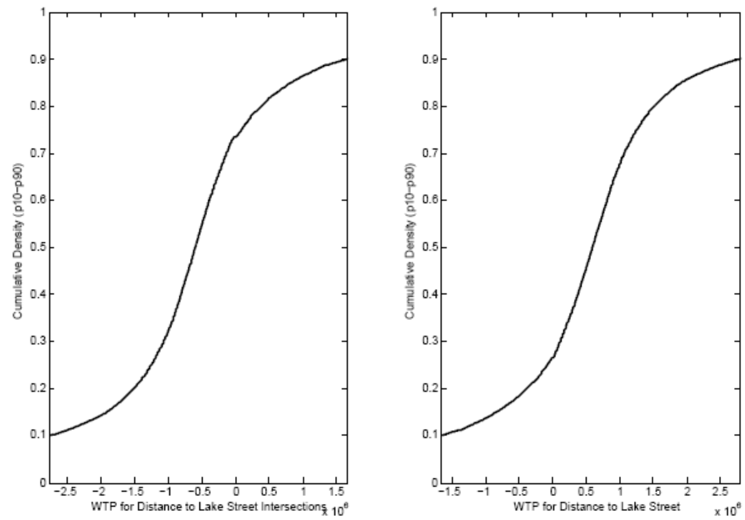

Figure 5: Willingness to Pay for Proximity to the Commercial Corridor- Single-family Homes.

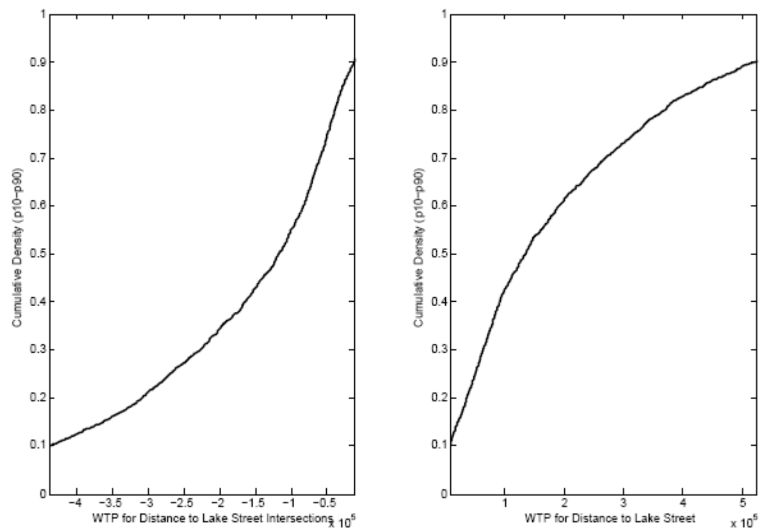

Figure 6: Willingness to Pay for Proximity to the Commercial Corridor- Multifamily Homes.

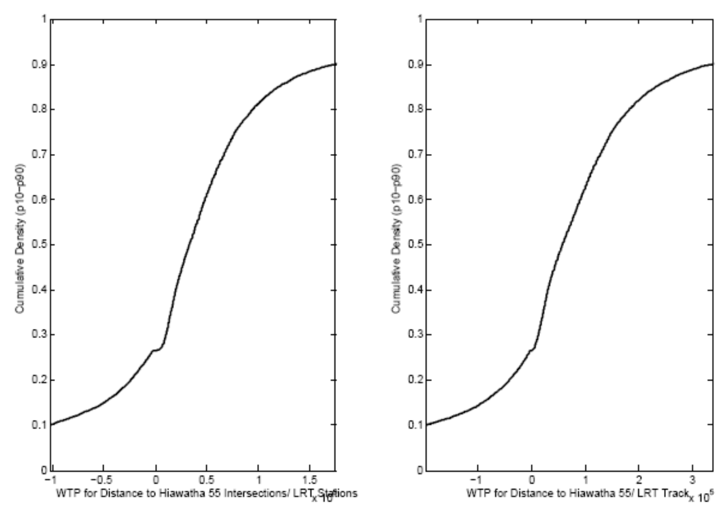

Figure 7: Willingness to Pay for Proximity to the Industrial/ Transportational Corridor- Single-family Homes.

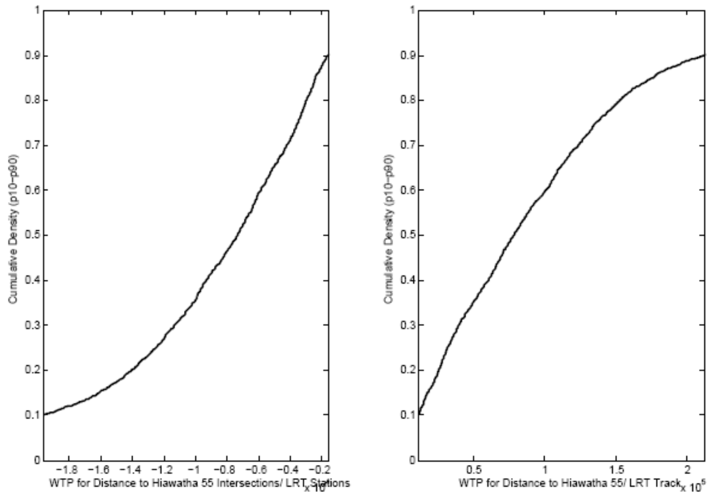

Figure 8: Willingness to Pay for Proximity to the Industrial/ Transportational Corridor-Multifamily Homes.

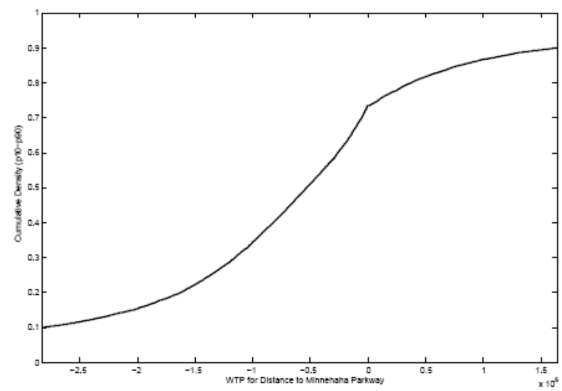

Figure 9: Willingness to Pay for Proximity to the Recreational Corridor- Single-family Homes.

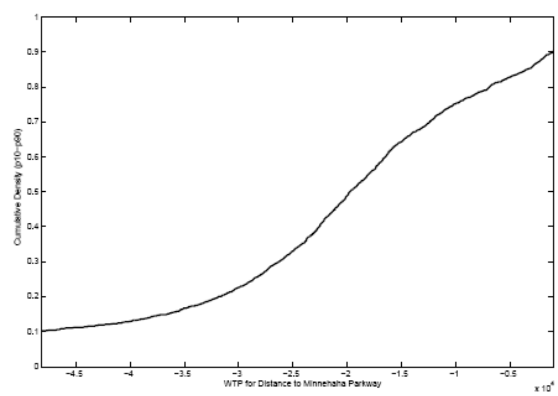

Figure 10: Willingness to Pay for Proximity to the Recreational Corridor- Multifamily Homes.

than those of multifamily homes.

It seems that overall, single-family homes households' WTP are, in absolute value, about 10 times larger than multifamily homes households. As explained earlier, the impact of comparable sales is more prominent on single-family homes. Given that the magnitudes of the coefficients from the first state of estimation do not differ dramatically across the two types of households, the reason for single-family homes households having much higher WTP here is that the indirect impact of other households' WTP are more effective in this case. Also, the proportion of this type of households caring for the accessibility effects of the various urban corridors is lower. One possible source for these findings is the mobility of the different types of households. Since multifamily home households value the amenities associated with the respective corridors more, it must be that they prefer not to travel further outside the area for other substitutes.

In terms of the distributions of the taste coefficient for the unobserved product characteristic, I find no particular interesting or educating results. For both types of the households, there is an even split on their valuations on this attribute. This is reassuring in a sense that since no stringent restrictions have been placed on this attribute, there should not have been any particular distribution pattern.

Taste Coefficients and Neighborhood Demographics. In this section I explain how different socioeconomic factors affect household's willingness to pay for the respective urban corridors. In the linear regressions, I use a set of demand shifters that characterizes and distinguish all block groups that are included in the study area. In particular, I regress WTP estimates on median household income and percentage of Hispanic, Latino, and African American population. The other socioeconomic factors are dropped due to the high degree of multicollinearity. The results for single-family homes are displayed in Table 5. Due to the high degree of spatial dependence of prices of this type of properties, WTP for any 10% changes in any of the structural and location attributes are highly sensitive to demographic changes in the area. Interestingly, the two factors have opposite impact on all the WTP estimates. Obviously households living in a high income area are willing to pay for new and larger homes, yet increasing the percentage of ethnic heterogeneity has the opposite effect. Indeed, this is true for all regressions and that changes in WTP in any attributes due to a $1000 increase in annual household income are offset by a one 1% increase in percentage of Hispanic, Latino, and African American population.

In terms of proximity to the urban corridors, single-family homes residents are willing to pay on average $1296 and $4272 respectively to avoid being 10% closer to highway entrances and exits and major intersections of the industrial corridor, given a $1000 increases in income or a one 1% decrease in ethnic composition. These estimates increase to $7027 and $8701 respectively when households are trying to avoid the nuisance effects of those corridors. Among all the corridors, estimates of households' WTP for 10% changes in proximity to the commercial corridor are most sensitive to changes in the socioeconomic factors used here. On average, households are willing to pay $79030 and $76923 respectively to avoid the nuisance effect of this corridor and to access its amenities. Obviously these estimates are inflated due to spatial nature of the data, since one cannot move closer to a major intersection of the corridor without being closer to the corridor itself. Hence households must substitute between the positive and negative externality of this corridor and the above estimates are indeed the upper bounds of what a typical household would pay.

The estimates for multifamily homes are reported in Table 8. The WTP estimates for this group of residents are far less sensitive to changes in income and composition of ethnicity groups in the area. Again, this is the direct result of the lack of spatial dependence among this type of properties. On average, it only takes a $226 increase in annual household income to offset the impact of a 1% increase in percentage of Hispanic, Latino, and African American population on WTP for housing attributes. Together with the low explanation power of ethnic composition on WTP, the estimates here show that the preferences of multifamily homes residents are not depending upon this socioeconomic factor.

Unlike single-family homes households, multifamily homes households response differently to changes in income in terms of their WTP for the different urban corridors. For a $1000 increase in annual income, these households are willing to pay about $38 and $3 to be 10% closer to the LRT stations and the freeway entrances/ exists respectively. Furthermore, they are paying about $105 and $526 for the same increases in proximity to the recreational corridor and major intersections of the commercial. The coefficients here reflect the households' shopping and dining

Table 5: Willingness to Pay and Socioeconomic Factors for Single-family Homes.

Single-family Homes					
	Income		Race*		
WTP	Coef.	Std. Err.	Coef.	Std. Err.	Adj. R-Sq.
yr_blt	99.17586	45.34484	-102750.7	49637.54	0.2002
lot_size	5.795073	2.582944	-5988.144	2827.466	0.218
gross_buil	12.55085	5.562502	-12978.1	6089.092	0.2173
total_bedr	1.756248	0.7410116	-1825.749	811.1616	0.2144
total_bath	4.066252	1.724882	-4273.102	1888.173	0.1751
dist_to_cbd	-37.24427	16.62308	38733.33	18196.75	0.1947
dist_to_st	4.17787	2.138457	-4366.953	2340.9	0.1411
dist_to_track	8.49749	4.321949	-8904.893	4731.1	0.1358
dist_to_35w	6.976616	4.137474	-7077.45	4529.16	0.1859
dist_to_35woo	1.285538	0.7177417	-1306.649	785.6889	0.1989
dist_to_park	-1.801662	1.769881	1799.619	1937.432	0.099
dist_to_lake	79.03011	35.50446	-82677.2	38865.6	0.1731
dist_to_lakei	-76.92316	34.71219	80420.99	37998.32	0.1739

* Percentage Hispanic, Latino & African American

habits can be altered easier than their traveling habits, when they are subjected to a small change in income. For the corridors' nuisance effects, households in this case are willing to pay $248 and $417 to avoid the LRT line and the freeway, and their WTP to avoid reconstructions of Lake Street is about $623. Again, the nuisance effects of the various corridors overwhelm their accessibility effects and this finding has been consistent throughout this study.

Table 6: Willingness to Pay and Socioeconomic Factors for Multifamily Homes.

Multifamily Homes					
	Income		Race*		
WTP	Coef.	Std. Err.	Coef.	Std. Err.	Adj. R-Sq.
yr_blt	6.388468	2.482188	-1541.182	2563.864	0.0119
lot_size	0.2007977	0.0797214	-30.34875	82.34467	0.0137
gross_buil	0.6573894	0.248895	-166.8864	257.0849	0.0122
total_bedr	0.184946	0.0660631	-40.86501	68.2369	0.0147
total_bath	0.0999186	0.0361189	-26.51518	37.30735	0.013
dist_to_cbd	-0.627505	0.2567049	99.97844	265.1517	0.0127
dist_to_st	-0.038071	0.0140858	9.909148	14.54933	0.0126
dist_to_track	0.4168804	0.1532131	-118.4181	158.2545	0.0121
dist_to_35w	0.2482309	0.1346564	14.07366	139.0872	0.0108
dist_to_35woo	-0.002715	0.0014181	-0.22152	1.464805	0.0122
dist_to_park	-0.105099	0.0414816	28.92345	42.84653	0.0107
dist_to_lake	0.6232362	0.2908802	24.51263	300.4516	0.0141
dist_to_lakei	-0.52597	0.2443275	-25.00137	252.3671	0.0145

* Percentage Hispanic, Latino & African American

CONCLUSION AND FURTHER WORK

In this paper, willingness to pay for various housing attributes and four distinct urban corridors in Minneapolis are estimated. The set of questions I address here are particularly timely, given that the city is expecting a return from investing in a light rail transit line as well as in redeveloping and restoring a major commercial corridor that connects the Twin Cities. The results show that there are significant differences between preferences for the types of residents in the data, and therefore supporting the interconnectedness of issues surrounding land use, zoning, urban policy and infrastructure planning. The impact of comparable sales is more prominent on single-family homes as the indirect impacts of other households' WTP are more effective in this case. Consequently this type of household's WTP estimates are much more responsive to changes in neighborhood socioeconomic factors. Clearly, "keeping up with the Joneses" does not play a key role in how multifamily homes households derive utility from housing and neighborhood attributes. Indeed, their preferences for proximity to the accessibility effects of the transportation corridors are persistently strong and changes in neighborhood demographics are more pertinent in this case. This, is the directly result of the greater geographical mobility of multifamily homes households. Nevertheless, the amenities associated with the various urban corridors are not substantial enough to outweigh their corresponding disamenities.

Due to data limitation, I do not present the result of demand for the two types of housing being studied here. In fact, it is not feasible to estimate demand for single-family homes since there is no product differentiation among this type of properties from the data. On the other hand, multifamily homes properties are categorized into at least 10 different types of structures according to MetroGIS. In a follow up study, I take the updated parcels data to analyze demand for multifamily homes. The soon to the available data set also includes condominium transactions. Given the recent fluctuations in the condominium side of the market, the analysis with the complete data set adds to the explanatory power of the model, allowing for the most current policy and land use implication that pertains to zoning and streetscaping of the city.

REFERENCES

Anselin, L. *"Spatial Econometrics: Methods and Models"*. Studies in Operational Regional Science. Springer-Verlad New York, LLC, 1988.

Anselin, L. *"Under the Hood. Issues in the Specification and Interpretation of Spatial Regression Models"*. Agricultural Economics, 17(3):247-267, 2002.

Bajari, P and Benkard, CL. *"Demand Estimation With Heterogeneous Consumers and Unobserved Product Characteristics: A Hedonic Approach"*. Journal of Political Economy,113(6):1239-1275, 2005a.

Bajari, P and Benkard, CL. *"Hedonic Price Indexes With Unobserved Product Characteristics, and Application to Personal Computers"*. Journal of Business and Economic Statistics, 1:61-75, 2005b.

Bajari, P and Kahn, ME. *"Estimating Housing Demand With an Application to Explaining Racial Segregation in Cities"*. Journal of Business and Economic Statistics, 23(1):20-33, 2005.

Bajari, P and Kahn, ME. *"Estimating Hedonic Models of Consumer Demand With an Application to Urban Sprawl"*. Hedonic Methods in Housing Markets: Pricing Environmental Amenities and Segregation. Springer Science + Business Media, LLC, 2008.

Bartik, TJ. *"The Estimation of Demand Parameters in Hedonic Price Models"*. Journal of Political Economy, 95(1):81-88, 1987.

Bayer, P and Ross, SL. *"Identifying Individual and Group Effects in the Presence of Sorting: A Neighborhood Effects Application"*. Working Paper, 2008.

Bayer, P, McMillan, R, and Rueben, K. *"An Equilibrium Model Of Sorting In An Urban Housing Market"*. NER Working Paper, 2005.

Beron, KJ, Hanson, Y, Murdoch, JC, and Thayer, MA. *"Hedonic Price Functions and Spatial Dependence: Implications for the Demand for Urban Air Quality"*. Advances in Spatial Econometrics. Springer-Verlad New York, LLC, 2004.

Berry, S. *"Estimating Discrete-Choice Models of Product Differentiation"*. RAND Journal of Economics, 25(2):242-262, 1994.

Berry, S, Levinsohn, J, and Pakes, A. *"Automobile Prices in Market Equilibrium"*. Econometrica, 64(4):841-890, 1995.

Can, A. *"Specification and estimation of hedonic housing price models"*. Regional Science and Urban Economics, 22:453-474, 1992.

Can, A and Megbolugbe, I. *"Spatial Dependence and House Price Index Construction"*. Journal of Real Estate Finance and Economics, 14:203, 1997.

Epple, D. *"Hedonic Prices and Implicit Markets: Estimating Demand and Supply Functions for Differentiated Products"*. Journal of Political Economy, 95(1):59-80, 1987.

Goetz, E, Ko, K, and Hagar, A. *"Differential Impact of the Hiawatha Light Rail Line on Property Values in Minneapolis "*. Working Paper, 2008.

Griliches, Z. *"Hedonic Price Indexes for Automobiles: An Econometric Analysis of Quality Change"*. The Price Statistics of the Federal Government. New York: National Bereau of Economic Research, 1961.

Haider, M and Miller, EJ. *"Effects of Transportation Infrastructure and Location on Residential Real Estate Values Application of Spatial Autoregressive Techniques"*. Transportation Research Record, 1722, 2000.

Heckman, J, Matzkin, R, and Nesheim, L. *"Nonparametric Estimation of Nonadditive Hedonic Models"*. cemmap Working Paper, 2005.

Matzkin, R. *"Nonparametric Estimation of Nonadditive Random Functions"*. Econometrica, 71(5):1339-1375, 2003.

McMillen, DP and McDonald, J. *"Locally Weighted Maximum Likelihood Estimation: Monte Carlo Evidence and an Application"*. Advances in Spatial Econometrics. Springer-Verlad New York, LLC, 2004.

Nevo, A. *"Measuring Market Power in the Ready-to-Eat Cereal Industry"*. Econometrica, 69(2):307-342, 2001.

Ortalo-Magne, F and Rady, S. *"Heterogeneity within communities: A stochastic model with tenure choice"*. Journal of Urban Economics, 64:1-17, 2008.

Petrin, A. *"Quantifying the Benefits of New Products: The Case of the Minivan"*. Journal of Political Economy, 110(4):705-729, 2002.

Rosen, S. *"Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition"*. Journal of Political Economy, 82(1):34-55, 1974.

Salvi, M. *"The Demand for Housing Attributes: Estimation of a Hedonic Model with Heterogeneity"*. Working Paper, 2007

1 The size of the map exceeds upload capability, please refer to http://www.econ.umn.edu/~kko/Ko_paper.pdf for a version of this paper including this map.

2 Some examples of properties that are considered multifamily homes are apartments, double bungalow, townhouse, triplex, sorority/fraternity housing, and nursing home.

3 Shape files for each urban corridor are created so that the shortest distance from each parcel can be calculated.

4 A shorter time frame for comparable sales is chosen here because of the recent fluctuations in the housing market. The distance restriction here is typical.

5 The size of the map exceeds upload capability, please refer to http://www.econ.umn.edu/~kko/Ko_paper.pdf for a version of this paper including this map.

6 This interstate highway is the western route of Interstate 35. It crosses the Mississippi River while running through Minneapolis and it is 39 miles long.

7 This east-west thoroughfare, has undergone multiple phrases of urban development reinvestment in the past 10 years.

8 Along the west side Hiawatha 55 there is a concentration of industrial land use and there is a light rail transit (LRT) line on the west that runs between downtown Minneapolis and the Mall of America in Bloomington. On the east side, there numerous old industrial buildings including grain elevators and infrastructures such as freight rail tracks.

9 This automobile/ bicycle pathway leads to Minnehaha Park on the east, which overlooks the Mississippi River.

10 In Bajari and Benkard (2005a), a local linear regression is used. Perhaps it will be worthwhile to investigate a locally weighted MLE as outlined in McMillen and McDonald (2004).

11 The magnitudes of the coefficients are reasonable in the sense that they do not deviate much from a model in which there is no spatial dependence, i.e. when ρ is set to zero.