On Space–Time Changes of Hedonic Prices for Single–Family Homes

Krister Sandberg*

CERUM and Department of Economics

Umeå University

SE-901 87 Umeå

Sweden

krister.sandberg@econ.umu.se

5th February 2003

Abstract

The level of and changes in prices for homes reflect the space-time dynamics in valuation of the underlying attributes connected with the objects. In this paper hedonic prices for single–family homes distributed over two Swedish counties are estimated for two years. Changes over space and time are estimated and analyzed. Spatial dependence is found to be influential. Hence, four variables are lagged with a spatial weight matrix. Additional spatial dependence in the error term is treated by Spatial Autoregressive Generalized Moment estimation. Structural and neighborhood characteristics together with accessibility measures are used as attributes. With GIS

*The author wish to thank The Swedish National Land Survey and Peder Axensten for providing and preparing data. Thanks also to Associated Professor Lars Westin, Professor Raymond J.G.M. Florax, and two anonymous referees for valuable comments on previous versions of the paper.

maps the price pattern over the region and its changes over time are identified. Especially the two county capitals, but also the municipality centers are found to influence the spatial price distribution positively. Over time, homes in locations with high accessibility to population, with water provided by the municipality or a very high standard experience improved property values.

***Keywords* :** Hedonic prices, Single–family homes, Spatial dependence, Heterogeneity

***Classification*[JEL] :** D46, D61, R20, R21

INTRODUCTION

The value of homes develops through a spatial dynamic process involving actors on both supply and demand sides. Property owners and city managers may want to improve the attributes of both private and public space in order to add values to their own properties, the city or the region. If supply does not match the demand for homes expressed by households (or the demand for premises by firms), the attractiveness of not only individual properties but also the village or a larger city may be set under pressure by competition from other villages, cities, or regions. Given that the economy becomes more knowledge based, this competition for movable labor by supply of "attractiveness" has been even more emphasized. Hence, the supply side clearly has an interest for how the valuation of characteristics associated with heterogeneous real estate located at different sites develop over time.

Since the seminal work by Haas (1922), Lancaster (1966), and Rosen (1974), the value of attributes associated with heterogeneous goods has been analyzed by hedonic price theory. A good may then be seen as a bundle of characteristics matching the household utility function. It is assumed that the buyer implicitly reveals his or her preferences for attributes through the price paid. Since in our case, the highest bidder purchases each home, it is assumed that the market prices gives the outer envelope of the valuation of each attribute by all households in the market.

The aim of this paper is to estimate the valuation of attributes connected with purchases of single–family homes in northern Sweden. Since we have data for two years within a five-year period, a comparative analysis may moreover be made. We may thus for the first time illustrate the price landscape for single–family homes in the region and initiate a discussion on the space-time evolution of the market. Such a discussion may in the sequel generate interesting policy conclusions for how the real estate market ought to develop in order to further improve the attractiveness of the region.

The empirical literature on hedonic prices for single–family homes is nowadays quite large but to a large extent based on American data, e.g. Blomquist et al. (1998) and Sinivatanidou (1996). Early exceptions are e.g. Wigren (1987), Englund et al. (1998), and Cheshire and Sheppard (1995) using Swedish and British data. However, studies are generally made for a single year and not with the aim to analyse changes over time.

A common feature of some other studies is their focus on a single specific characteristic and its influence on prices. Blomquist (1998), Benson et al. (1998), Shultz and King (2001), Beron et al. (2001), and Bond et al. (2002) analyses the impact of view amenities. The importance from landscaping on homes and their surroundings was studied by Des Rosiers et al. (2002). Clark and Allison (1999) analyzed the impact of risk perception on values. The impact of increased accessibility through a new bridge was studied in Smersh and Smith (2000) while Thompson and Hills (1999) studied Internet connections. Bogart and Cromwell (2000) analyzed the impact of a re-distribution of schools on home values.

In our case we are, as Wigren (1987) and Englund et al. (1998), instead interested in all attributes influencing the price of individual homes. A set of such, although qualitative, studies of the Swedish market, e.g. Lindgren and Rosberg (1992), and Andersson (1998) found that the distance to the Central Business District, the level of service and waterfront location influence prices positively. In this study, we combine the more general approach of previous quantitative studies with the richer detail in describing the characteristics found in qualitative studies.

Recently, the attention in the hedonic price literature towards spatial dependence (spatial autocorrelation) has increased. Can and Megbolugbe (1997), Pace and Gilley (1997), Basu and Thibodeau (1998), Brasington (1999), as well as Tse (2002) are examples in this direction. In our case corrections for spatial dependence in the material is also in focus while we estimate our models.

The paper is organized as follows. The next section treats the theory of hedonic prices and spatial econometrics. This is followed by data description. The empirical examination is outlined in the fourth section, followed by conclusions in the final section.

HEDONIC PRICE THEORY AND SPATIAL ECONOMETRICS

Hedonic prices are defined as implicit prices of attributes and are revealed through observed prices on differentiated goods and the specific amounts of characteristics associated with them, e.g. Lancaster (1966).

The concept of implicit or hedonic prices was first formalized in Rosen (1974). The good considered, e.g. a home, may be described by m characteristics. Each home is then represented by the vector $\boldsymbol{z} = (z_1, \ldots, z_m)$. An element z_i measures the amount of the ith characteristic embedded in each home. The price function based on this vector of characteristics is the hedonic price function $p(\boldsymbol{z}) = p(z_1, \ldots, z_m)$.

Household preferences are represented by the utility function:

$$U = u(\boldsymbol{z}, \boldsymbol{c}, \boldsymbol{\alpha}) \tag{1}$$

where $\boldsymbol{z}$ is consumption of the single–family home, $\boldsymbol{c}$ is consumption of a composite good, and $\boldsymbol{\alpha}$ is a vector of parameters that characterize the household preferences. The price a household is willing to pay for a home is derived from the utility function as a function of the embedded characteristics, the household income (M), and an achieved utility level. This gives the household bid rent function:

$$\gamma(\boldsymbol{z}, M, U, \boldsymbol{\alpha}) \tag{2}$$

and implicitly:

$$U = u(\boldsymbol{z}, M - \gamma, \boldsymbol{\alpha}) \tag{3}$$

The derivative of the bid rent function, $\frac{\partial \gamma}{\partial z_i}$, gives the rate at which the household would be willing to change its expenditure on the home when characteristic i increases, while keeping other levels constant.

Problem: *The household chooses a single–family home with characteristics* $\boldsymbol{z}$*, and its consumption of the composite good* $\boldsymbol{c}$ *by solving:*

$$\max_{\substack{\boldsymbol{z},\boldsymbol{c} \\ \text{s.t. } M \geq p(\boldsymbol{z}) + \boldsymbol{c}}} u(\boldsymbol{z}, \boldsymbol{c}, \boldsymbol{\alpha}) \tag{4}$$

The equilibrium market price, $p(\boldsymbol{z})$, reflects the market valuation of a single–family home with a set of attributes given i.e. amortization, available interest schemes, and expected costs for repair and improvements during the entire period that the household intends to keep the single–family home.

Through the first order conditions we get:

$$\frac{u_i}{u_c} = p_i \ \forall i \tag{5}$$

where $u_i = \frac{\partial u}{\partial z_i}$, $u_c = \frac{\partial u}{\partial \boldsymbol{c}}$, and $p_i = \frac{\partial p}{\partial z_i}$ the hedonic price of characteristic i.

A combination of the first order condition (5) and the implicit differentiation of (3) yields that the optimal choice of a single–family home by the household is characterized by equality between the slope of the bid rent and the hedonic price with respect to each characteristic. Thus, the household locates so that its indifference curve is tangent to the price gradient. This justifies the use of the hedonic price approach in the analysis of the market for single–family homes when the mix of attributes is developed not far away from the current market situation.

The vector $\boldsymbol{z}$ consists as mentioned of a set of characteristics which are subjectively determined by the household. This vector of characteristics is usually divided into three broader groups, structural ($\boldsymbol{s}$), neighborhood ($\boldsymbol{n}$), and accessibility ($\boldsymbol{a}$) attributes with $\boldsymbol{\omega}$, $\boldsymbol{\eta}$, and $\boldsymbol{\psi}$ as the corresponding parameter vectors. Hence, the hedonic price function of a general regression model can be formulated as:

$$p(\boldsymbol{z}) = f(\boldsymbol{s}, \boldsymbol{n}, \boldsymbol{a}, \boldsymbol{\omega}, \boldsymbol{\eta}, \boldsymbol{\psi}) + \boldsymbol{\varepsilon} \tag{6}$$

Before we move to the estimation part, spatial dependence, or spatial autocorrelation, in the sample must be considered. In other words, there might be some inherent systematic dependence between the observations unexplained by traditional variables. In the literature, two types of specification are commonly used.

The first type arises because the prices of neighboring single–family homes move together due to common or correlated unobservable variables i.e. lack of stochastic independence between observations. This was brought to public attention by among others Cliff and Ord (1972) and Bodson and Peeters (1975). See also Cliff and Ord (1973) for a further discussion of the problem. If unsolved, this problem will violate the standard error assumptions under normality of the linear regression model, resulting in inefficient estimates. To solve this the spatial dependence is incorporated via an autoregressive error term:

$$\begin{aligned} y &= \boldsymbol{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon} \qquad (7) \\ \boldsymbol{\varepsilon} &= \lambda \boldsymbol{W} \boldsymbol{\varepsilon} + \boldsymbol{\xi} \end{aligned}$$

where $\boldsymbol{W\varepsilon}$ is a spatial lag for the error term, λ is the autoregressive coefficient and $\boldsymbol{\xi}$ is a vector of well-behaved error terms $\boldsymbol{\xi} \backsim N(0, \delta^2 \boldsymbol{I})$.

The second type of spatial dependence is present if spatial correlation in the dependent variable between observations exists. This means that the transaction price on one single–family home is influenced by the prices for nearby home transactions and vice versa, cf. Anselin (1988) and Can (1992). If ignored, the OLS estimates will be biased and lead to incorrect inference. Adding a spatial lag solves the spatial dependence problem:

$$y = \rho \boldsymbol{W} y + \boldsymbol{X\beta} + \boldsymbol{\varepsilon} \tag{8}$$

where ρ is an autoregressive coefficient. $\boldsymbol{W}$, with elements w_{rs} corresponding to observation pair r and s, is the generalized weight matrix, and $\boldsymbol{W}y$ is the spatially lagged dependent variable.

However, this solution is not flawless unless you believe in global spatial autocorrelation as shown by Anselin (2003). If the dependence is restricted more locally, then the specification must be altered, due to unwillingly induced heteroscedasticity. Since we believe that the influence is cut–off at some distance we use a model by Florax and Folmer (1992), considering only local spillovers in some of the explanatory variables. In case of remaining spatial dependence among the error terms after this correction a type one correction is added.

$$\begin{aligned} y &= \boldsymbol{WX\rho} + \boldsymbol{X\beta} + \boldsymbol{\varepsilon} \qquad (9) \\ \boldsymbol{\varepsilon} &= \lambda \boldsymbol{W\varepsilon} + \boldsymbol{\xi} \end{aligned}$$

The hedonic price theory added with spatial econometrics is a combination of (6) and (9):

$$\begin{aligned} p(\boldsymbol{z}) &= \boldsymbol{W}\boldsymbol{X}\boldsymbol{\rho} + f(\boldsymbol{s}, \boldsymbol{n}, \boldsymbol{a}, \boldsymbol{\omega}, \boldsymbol{\eta}, \boldsymbol{\psi}) + \boldsymbol{\varepsilon} \\ &= \boldsymbol{W}\boldsymbol{X}\boldsymbol{\rho} + \boldsymbol{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon} \\ \boldsymbol{\varepsilon} &= \lambda \boldsymbol{W}\boldsymbol{\varepsilon} + \boldsymbol{\xi} \end{aligned} \tag{10}$$

Another important issue is heterogeneity, or structural regimes, in the data. This means that attributes are valued differently in some part of the geographical area. If not acknowledged, variables may be ruled out as insignificant or differences may be averaged out. We will then miss important information on hot/cold spots. For this reason, two variables, (LN AGE and GRAVITY), are divided into three groups. The first group consists of the two regional centers, the second of other coastal municipalities and the third group consists of all the inland municipalities. Both variables were tested for structural instability and a test of stability of the individual coefficients with a null hypothesis of a joint common coefficient for all single–family homes using a spatial Chow–Wald test, see Anselin (1990). The test indicated that both show signs of being divided.

ATTRIBUTES OF THE REALIZED SALES OF SINGLE–FAMILY HOMES 1994 AND 1999

Our data covers the market for single–family homes in the counties Västernorrland and Västerbotten in the northern part of Sweden. Data are available for two years, 1994 and 1999, and consists of 2,778 observations of realized sales in 1994 and 4,538 sales for the year 1999. The spatial distribution of sold homes is presented in Figure 1. Each home is indicated by a dot.

Although the number of sales is larger in the second year, the spatial distribution of sales is rather similar and obviously reflects the underlying pattern of homes in the counties. Most transactions occur along the coast, and especially near the regional centers, Umeå (the cluster west of the small island) and Sundsvall (the south east cluster). A closer look at the maps indicates that the pattern also follows the inland roads. Compared with a "normal" year during the nineties, the first year represents a low number of sales while during the last year, due to a change in taxation regulations, the number of sales is larger than usual. So far, it has not been possible to identify the impact of those oscillations on the results presented below.

In 1994, the total population in the region was 519,000 inhabitants, a number that was reduced to 510,000 inhabitants in 1999. Those were distributed over 22 municipalities, where the densest municipalities are found along the coast. In between the two years all municipalities, except Umeå, the largest municipality, faced a population decrease. This pattern follows the overall movement of people towards the larger cities during the period and we may expect this to be shown as a general increase of home prices along the eastern coast, while the reverse may be expected in the inland. However, the standard of each home, the accessibility to various services etc. will obviously also have a strong influence on the price and we may not a priori conclude that each sold home at the coast have faced an increased value at the end of the period.

Before we continue it may be appropriate to analyze the descriptive statistics for our data and to discuss expected signs of the variables that will be used in the estimation. Data on the characteristics of each home are from the yearly property taxation for Sweden. Some variables have been added or removed between the years, as indicated by lines in the columns in Table 1.

In the first row, the *dependent variable*, the natural logarithm of the price, LN PRICE is given. The average price has after correction for inflation increased from 391,000 SEK in 1994 to 478,000 SEK during the five years, i.e. an average annual increase of around 4.5 percent. This is in line with an overall increase of incomes during the period.

The *independent variables* are, as mentioned earlier, divided into three groups based on their structural-, neighborhood-, and accessibility characteristics.

The *structural variables* consist of the characteristics of the specific homes. Obvious attributes to be included as continuous variables are floor size, lot size, and the age of the home. The two former are expected to have a positive impact on the price while the latter is expected to influence price negatively.

The remaining structural variables are treated as dummies. Semidetached homes or homes linked by a garage represents the base case while ordinary homes are represented by a dummy. The ordinary solution is expected to have a positive sign. If a home has been extended during its lifetime, the value may increase and a positive sign is expected. Specific annotations about the lot or the home itself are indicated for some of the observations. Those are treated as dummies and are assumed to have negative/positive signs for bad/good attributes.

Another set of dummies concerns the water supply. The default here is municipality supplied water and WC. Dummies for other forms of water supply ought to have negative signs because of the extra time that have to be spent on maintenance etc. and for possible problems with water quality.

The standard of each home is graded by a system of standard points. The points are here divided into six groups each given a dummy. All dummies are expected to have positive signs since they are measured against the lowest group that includes values 0–15.

The second group, the *neighborhood attributes*, deals with the neighborhood of each home and the overall situation in the municipality where the home is located. Net migration, measured at the municipality level, is a proxy for the demand on the real estate market in each municipality. A positive net migration should increase the demand and a positive sign is therefore expected. To investigate the importance of imbalance at the labor market, the natural logarithm of the unemployment quotient (unemployed/population) is included. A positive quota means that a large share of unemployed in the population drives prices down. A high interest rate at the date of purchase makes borrowing expensive and increases the risk in connection with a purchase. The sign is therefore expected to be negative. The impact of the municipality tax is more difficult to predict. The average municipality tax was 20.2 percent in 1994 and increased to 22.4 percent five years later. A high tax could be an indication of improved public service but it could also be an indication of financial strains. The sign is nonetheless expected to be positive as an indication of a high level of public service. The next variable measures the average income level for people over 20 years of age. It is included to reflect the economic situation among the households in the municipality. The average income increased by almost 30,000 SEK in real terms between 1994 and 1999. At the same time, the income spread between municipalities also increased during the period. The sign with respect to prices on homes ought to be positive. For homes located at or near a beach, a positive sign is expected due to the presence of the waterfront. In 1994, 77 percent of the transactions were transactions in built–up areas, a figure that increased to 81 percent in 1999. The sign for the built–up area dummy is expected to be positive. Finally, a dummy for the southern county of Västernorrland was included to test for other overall differences between the two counties. The sign of the variable is ambiguous.

The third and last group contains the *accessibility attributes*. A combination of distance and population is used, defined as:

$$GRAVITY = \sum_{1}^{22} \frac{POP_j}{D_{ij}} \tag{11}$$

Hence, the variable is the sum of the quotients of population in the 22 municipalities divided by the distance (as crow flies) between the observation i and each municipality CBD j. This implies that a home is valued differently depending on the number of people that has accessibility to the home alternatively the number of people one may reach from the home. A large population in the vicinity enhances the value of a home. If this is correct, a positive sign is what to expect. The last two accessibility attributes are two dummy variables, indicating whether a home lies within a 5 km range of each of the European roads E4 and E12. The implication is that accessibility to major road communications should affect the value positively.

THE EMPIRICAL EXAMINATION

The results of our regressions are presented in Table 2 for the year 1994 and in Table 3 for the year 1999. Each table consists of five regressions in order to follow the impact of different specifications in an easy way. The first regression in each table is an Ordinary Least Square regression without any spatial considerations. The floor and lot sizes are as expected positive for the value of the home in both years, while the age of the home has a negative impact. In the event that a home has been extended also increases the value. The dummy variable indicating lack of maintenance is significantly negative for 1994 data but not for 1999. Four kinds of water supply variables are significant in 1994 and 1999. Interestingly, the sign of the variable for only summer water and "own" WC is positive. This fact may indicate that those homes have some other qualities, such as attractive surroundings, not captured in the data. The standard point dummy variables all have the expected positive sign, with higher estimates for higher points except for the top class that has a slightly reduced value in 1994. As expected a positive net migration improves the values in both years. The level of the interest rate is only significant for 1999 and has the expected negative sign. The estimated parameters for municipality tax and average income are both significant with a positive sign. The waterfront location is as indicated valued positively, at least if the home is located close to the beach. The value of a home is improved when located in a built–up area and in the most southern county of Västernorrland. When it comes to the accessibility measures, the dummy variables for the two European roads are significant and positive for both years. The gravity variable is also positive and slightly higher in 1994. The overall fit is quite good, 71% in 1994 although a bit lower, 65% in 1999, a pattern that to a large extent continues for the remaining regressions.

To investigate the size of neighborhood spillovers, the OLS regression is in column two extended with four spatially lagged variables. The variables (LN FLOORSIZE, LN LOTSIZE, LN AGE, and GRAVIT) are lagged with a spatial weight matrix (indicated with prefix W). It was decided to use a matrix that consisted of the row standardized inverse distance between all observations with a distance cut–off at 48 km. This is the minimum allowable distance between observations in the 1994 data set, with the implication that each observation has at least one neighbor. For comparability between the years, the same distance cut–off was used for the 1999 data set.

In this estimation, the constant term for 1994 becomes insignificant. The floor size impact is slightly smaller than before. But we have instead caught the importance of the floor size of homes in the neighborhood. Large homes in the neighborhood are valued positively for both years. The magnitude of the lot size effect has increased. On the other hand are large lot sizes in the neighborhood negative for the value. The age effect is in both years negative, as is the neighborhood age effect. The gravity variable that previous had a positive value is now negative for the year 1994, while the lagged gravity variable has a stronger positive sign. Five years later, only the lagged variable is significant and positive. But in both cases we may conclude that a home located in an area where the accessibility in the surroundings is high seems to be more important than the accessibility where the home itself is located.

As mentioned earlier, heterogeneity is also accounted for. In the third column, an OLS regression is presented where the non weighted age and gravity variables instead are divided into three structural shift variables based on the geographical location of the homes. Hence, the two previous variables are exchanged by these six new variables. As was mentioned above, the first group of locations consists of the two regional centers, the second group consists of other coastal municipalities, and thirdly there is a group of inland municipalities. The value of homes in the first group (Umeå and Sundvall), is found to be least reduced by aging. Homes in the other coastal municipalities are to a larger degree influenced by the age but the largest impact on the value of a home from aging is found in the inland. One may also observe that the influence of neighbohood spillovers from the age of homes become insignificant in 1999.

Also the lagged gravity variable is positive in 1994 while insignificant in 1999. In 1994, the location variable for Umeå–Sundsvall is significant but negative while it becomes positive for the inland municipalities. In 1999 the Umeå–Sundsvall variable is negative while both variables for the other groups are positive and significant. The fixed effect variables (same grouping as above with the third group as the base case) gives new intercepts to the different groups. The fixed effect variables have a negative and significant value if the home is located in one of the first two groups of municipalities. They are in 1999 still negative but smaller. The fixed effect for other coastal municipalities is only significant at the 10% level in 1994 with a negative value.

To deal with additive heteroscedasticity, we use our information regarding the location of each home. That is, the same groups as above are used. A category variable is created and given the value 1 if the home is located in either Umeå or Sundsvall. If located in another costal municipality it is assigned the value 2. Homes in inland municipalities are given the value 3. In the estimation we make use of a Feasible Generalized Least Squares regression method. The results from this regression may be found in the fourth columns. Apart from some minor magnitude changes, the results do not differ to much from the previous regressions. The category variables are positive and significant for both years.

The final regression in the tables presents a test for remaining spatial dependence in the error terms. In both cases, this is made by use of a Spatial Autoregressive Generalized Moments (SAR–GM) estimator, cf. Kelejian and Prucha (1999). The motivation for this choice, instead of the more common maximum likelihood estimator, is the fact that SAR–GM accepts non–normality and heteroscedasticity. The weight matrix used for the error terms is the same as before when we lagged some of the independent variables. The autoregressive coefficient λ is 0.5 in 1994 and a bit higher, 0.82 in 1999.

A central part of our study is to compare hedonic prices over time. It is made by comparing the parameter estimates for the two years. Comparisons are only made for variables present for both years and if at least one of the years presents a significant value (the insignificant value is in that case given the value 0). The comparison is based on the fifth regression respectively.

We may observe that the importance of floor size seems to have been reduced slightly. Instead the impact of lagged lot size has become larger, a sign of divergence. We may also conclude that the importance of the negative age effect seems to be stronger over the whole study area. The fixed effect for the first group is larger in 1999 compared to 1994. All standard point variables have experienced a decrease in importance except for the top class, which instead has increased slightly. The municipality tax, i.e. the level of public service and the average income are more important for the values of homes in the year 1999. It is not equally important to live near the beach, in a built–up area, or in the county of Västerbotten anymore. The lagged gravity variable is also reduced in 1999. The importance of the local gravity variable has on the other hand increased. The closeness to major roads has developed differently. The accessibility to the E4 has increased in value while the E12 is still positive but it adds less to the value of a home.

In order to give a graphical illustration of the spatial pattern of the predicted values for LN PRICE across the counties two smoothing maps, one for each year, are presented in Figure 2. The predicted value for each home is calculated based on the parameter estimates from the fifth regressions for both years. The reader may clearly detect the concentration of high values around the two regional centers and in the other municipalities along the coast. Lower prices are found in the inland area.

The changes in the real estate market between the two years are also illustrated using a third map, Figure 3. Here, the difference between the predicted prices between the two years is illustrated, in terms of standard deviations from the mean. The darker grey areas have met a significant increase in prices during the period. This is particularly noticeable in the Umeå region, an indication of regional expansion. Still, this regional expansion is rather concentrated from a geographic perspective. The standard of the infrastructure around Umeå has been rather unchanged so the radius of about 60 km surrounding Umeå has not increased during this five-year period, instead the values of homes inside but near the border has increased most. Some minor increases are found north and south of Umeå. Another interesting area may be found southwest of Umeå. The explanation for this increase is not a particularly expanding region but instead a recovery from very low prices in 1994. The opposite applies to the western part of the map. The previous boom in the skiing resort area has now ebbed out and as a result we may witness lower prices in this area. But this decrease in prices is not exclusive for the most western part. Most of the inland municipalities have experienced price reductions.

CONCLUSIONS

This paper has dealt with the valuation of attributes connected with purchases of single–family homes in northern Sweden in a comparative way using hedonic price theory and spatial econometrics.

We have shown that space matter. This is particularly noticeable when the regressions are expanded to treat different kinds of spatial dependence and compared both within a year and between the two years. When the specification of the model is expanded the parameter estimates changes in sign, level, and significance.

The observed changes in the price landscape between the two years indicate a concentration of objects with high prices in the Umeå and Sundsvall areas. We may also observe a significant increase of home values in the municipalities surrounding the municipality of Umeå, a sign of greater dependence among the municipalities in this area and may conclude that the region has witnessed a outward growth during the five years. A decrease in prices is on the other hand found in the inland to the west.

The standard of each home at the time of purchase has become less important to the buyer. This is in accordance with the decreased influence we have observed for the age variable. Instead location matters and the inflow of people and incomes to the major regions becomes a strong force behind home values.

Further research would include data for additional years in order to facilitate the dynamic development analysis of the real estate market in this part of Sweden. Since the influence of spatial dependence is found to influence the results it is also important to enhance this field of research.

Table 1: The Descriptive Statistics for the years 1994 and 1999. All prices are expressed in year 2000 values

Variable	Unit	Mean_94(st.dev)	Range_94	Mean_99(st.dev)	Range_99	Sign
LN PRICE	ln price	5.97(0.79)	0.74–7.87	6.17(0.69)	2.21–8.02	
LN FLOORSIZE	ln m^2	4.80(0.35)	3.22–6.07	4.85(0.28)	3.64–6.55	(+)
LN LOTSIZE	ln m^2	7.06(0.86)	4.36–11.28	6.99(0.78)	4.36–10.72	(+)
LN AGE	year	3.47(0.68)	0.00–5.28	3.59(0.55)	0.69–5.40	(-)
Ordinary house	dummy	0.86(0.34)	0–1	0.86(0.35)	0–1	(+)
If added floor space	dummy	0.07(0.24)	0–1	0.08(0.27)	0–1	(+)
Noise	dummy	0.01(0.10)	0–1	0.005(0.07)	0–1	(-)
No electricity	dummy	0.0003(0.02)	0–1	-	-	(-)
Construction error	dummy	0.001(0.03)	0–1	0.002(0.04)	0–1	(-)
Moisture	dummy	-	-	0.003(0.06)	0–1	(-)
Difficult lot	dummy	0.004(0.06)	0–1	0.0002(0.01)	0–1	(-)
Renovation object	dummy	-	-	0.0002(0.01)	0–1	(-)
Radon	dummy	-	-	0.006(0.08)	0–1	(-)
No maintenance	dummy	0.002(0.05)	0–1	0.002(0.05)	0–1	(-)
Indor swimmingpool	dummy	0.0007(0.03	0–1	-	-	(+)
Historically important	dummy	-	-	0.0002(0.01)	0–1	(?)
Local part	dummy	-	-	0.0002(0.01)	0–1	(+)
Less than 50,000 SEK	dummy	-	-	0.006(0.007)	0–1	(-)
Other annotations	dummy	0.006(0.07)	0–1	0.007(0.08)	0–1	(?)
Municip. water, own WC	dummy	0.03(0.17)	0–1	0.03(0.17)	0–1	(?)
Municip. water, no WC	dummy	0.0007(0.03)	0–1	-	0–1	(-)
Own water, municip. WC	dummy	0.007(0.08)	0–1	0.007(0.08)	0–1	(?)
Own water and WC	dummy	0.11(0.32)	0–1	0.09(0.29)	0–1	(?)
Own water, no WC	dummy	0.003(0.05)	0–1	-	-	(-)
Municip. summer water WC	dummy	-	-	0.0002(0.01)	0–1	(-)
Own, summer water WC	dummy	0.005(0.07)	0–1	0.002(0.04)	0–1	(-)
Own summer water, no WC	dummy	0.003(0.05)	0–1	0.0004(0.02)	0–1	(-)
No water, municip. WC	dummy	-	-	0.0002(0.02)	0–1	(-)
No water, own WC	dummy	0.001(0.04)	0–1	0.0004(0.02)	0–1	(-)
No water or WC	dummy	0.003(0.05)	0–1	0.0004(0.02)	0–1	(-)
Standard points 16–20	dummy	0.12(0.33)	0–1	0.07(0.26)	0–1	(+)
Standard points 21–25	dummy	0.26(0.44)	0–1	0.27(0.45)	0–1	(+)
Standard points 26–30	dummy	0.27(0.44)	0–1	0.38(0.49)	0–1	(+)
Standard points 31–35	dummy	0.22(0.42)	0–1	0.20(0.40)	0–1	(+)
Standard points 36–45	dummy	0.10(0.30)	0–1	0.06(0.24)	0–1	(+)
Standard points 46-50(52)	dummy	0.002(0.04)	0–1	0.003(0.06)	0–1	(+)
NET MIGRATION	persons	207.1(500.2)	-176–1321	-150.75(155.2)	-347–100	(?)
LN (UNEMPL/POP)	quotient	-3.0(0.15)	-3.92–2.76	-3.4(0.22)	-3.07–3.07	(-)
2 YEARS INTEREST RATE	%	10.78(1.13)	8.50–12.00	5.68(0.63)	4.50–6.45	(-)
MUNICIPALITY TAX	%	20.17(0.48)	19.05–20.85	22.41(0.46)	21.29–23.15	(?)
AVERAGE INCOME 20+	K SEK	156.38(7.84)	136.0–165.7	183.90(9.19)	158.68–194.14	(+)
Beach	dummy	0.01(0.12)	0–1	0.01(0.12)	0–1	(+)
Near beach	dummy	0.03(0.18)	0–1	0.02(0.15)	0–1	(+)
Built–up area	dummy	0.77(0.42)	0–1	0.81(0.38)	0–1	(+)
Västernorrland	dummy	0.52(0.50)	0–1	0.50(0.50)	0–1	(?)
GRAVITY	m/pop.	21.49(27.51)	1.68–454.27	23.79(34.53)	1.56–893.26	(+)
Within 5 km range from E12	dummy	0.17(0.38)	0–1	0.21(0.41)	0–1	(+)
Within 5 km range from E4	dummy	0.55(0.50)	0–1	0.61(0.49)	0–1	(+)

Table 2: The 1994 Regression Results for LN PRICE. ***, **, and * indicate a significant value at the 1, 5, or 10% level.

Variable	OLS_1	OLS_2	OLS_3	FGLS	SAR–GM
λ					0.50(***)
Constant	-2.65***	-1.11	-0.35	-1.07	-1.66
LN FLOORSIZE	0.57***	0.53***	0.53***	0.53***	0.54***
W_LN FLOORSIZE		0.28***	0.23**	0.34***	0.46***
LN LOT SIZE	0.10***	0.12***	0.12***	0.12***	0.12***
W_LN LOT SIZE		-0.11**	-0.09**	-0.10**	-0.14***
LN AGE	-0.30***	-0.27***			
W_LN AGE		-0.21***	-0.20***	-0.13***	-0.09
LN AGE_*1*			-0.15***	-0.17***	-0.18***
LN AGE_*2*			-0.30***	-0.32***	-0.32***
LN AGE_*3*			-0.39***	-0.41***	-0.40***
d_Fixed effect_1			-0.59***	-0.60***	-0.54***
d_Fixed effect_2			-0.21*	-0.23*	-0.21
d_Ordinary house	-0.01	0.02	-0.02	-0.01	-0.01
d_If added floor space	0.09***	0.07**	0.08**	0.08***	0.08***
d_Noise	0.07	0.10	0.10	0.08	0.06
d_No electricity	-0.11	-0.11	-0.21	-0.24	-0.24
d_Construction error	-0.33	-0.25	-0.19	-0.15	-0.16
d_Difficult lot	-0.07	-0.08	-0.07	-0.08	-0.07
d_No maintenance	-0.69***	-0.65***	-0.61***	-0.62***	-0.57***
d_Indoor swimmingpool	-0.21	-0.23	-0.24	-0.22	-0.27
d_Other annotations	-0.02	-0.07	-0.09	-0.12	-0.15*
d_Municip. water, own WC	0.05	-0.002	-0.003	0.03	-0.03
d_Municip. water, no WC	-0.14	-0.04	-0.10	0.11	-0.07
d_Own water, municip. WC	-0.04	-0.02	-0.006	-0.04	-0.03
d_Own water and WC	-0.09***	-0.13***	-0.11***	-0.10***	-0.09***
d_Own water, no WC	-0.51***	-0.49***	-0.44***	-0.27*	-0.26*
d_Own, summer water WC	0.04	0.002	-0.007	0.01	0.02
d_Own summer water, no WC	0.13	0.05	0.01	-0.04	-0.05
d_No water, own WC	-0.58***	-0.64***	-0.66***	-0.53***	-0.53***
d_No water or WC	-0.43***	-0.51***	-0.47***	-0.51***	-0.48***
d_Standars points (16–20)	0.32***	0.32***	0.34***	0.30***	0.29***
d_Standard points (21–25)	0.58***	0.57***	0.58***	0.51***	0.50***
d_Standard points (26–30)	0.76***	0.74***	0.75***	0.67***	0.65***
d_Standard points (31–35)	0.82***	0.79***	0.80***	0.72***	0.70***
d_Standard points (36–45)	0.89***	0.86***	0.89***	0.80***	0.77***
d_Standard points (46–50)	0.84***	0.74***	0.78***	0.62***	0.69***
NET MIGRATION	0.0002***	0.0001***	$8 \cdot 10^5$**	$8 \cdot 10^5$***	$6 \cdot 10^5$
LN UNEMP/POP	-0.06	-0.06	-0.13***	-0.12	-0.12
INTEREST RATE, 2 YEARS	0.008	0.007	0.008	0.01	0.01
MUNICIPALITY TAX	0.07***	0.06***	0.05**	0.06***	0.07*
AVERAGE INCOME	0.02***	0.01***	0.01***	0.01***	0.01***
d_Beach	0.29***	0.29***	0.29***	0.27***	0.29***
d_Near beach	0.09*	0.10**	0.10**	0.09	0.09**
d_Built–up area	0.21***	0.21***	0.19***	0.21**	0.19***
d_Västernorrland	0.07***	0.14***	0.12***	0.11***	0.10***
GRAVITY	0.003***	-0.002***			
W_GRAVITY		0.01***	0.01***	0.01***	0.01***
GRAVITY_*1*			-0.003***	-0.002***	-0.002***
GRAVITY_*2*			-0.0003	0.0002	0.0002
GRAVITY_*3*			0.004**	0.004*	0.004
d_Within 5 km range of E*12*	0.20***	0.11***	0.13***	0.13***	0.14***
d_Within 5 km range of E*4*	0.18***	0.08***	0.10***	0.10***	0.10***
CATERGORY_1				0.07***	0.07(***)
CATERGORY_2				0.17***	0.16(***)
CATERGORY_3				0.27***	0.26(***)
R^2	0.71	0.73	0.74	0.72	0.72
R^2*-adj.*	0.71	0.73	0.74		
Sq.corr				0.74	0.74
SIG-SQ	0.18	0.17	0.16		
Observations/ Iterations	2778	2778	2778	2778	2778 / 6

Table 3: The 1999 Regression Results for LN PRICE. ***, **, and * indicate a significant value at the 1, 5, or 10% level.

Variable	OLS_1	OLS_2	OLS_3	FGLS	SAR–GM
λ					0.82(***)
Constant	-4.34***	-2.42***	-0.005	-0.46	-3.91**
LN FLOORSIZE	0.55***	0.49***	0.50***	0.49***	0.51***
W_LN FLOORSIZE		0.80***	0.64***	0.81***	0.60***
LN LOT SIZE	0.06***	0.12***	0.11***	0.09***	0.10***
W_LN LOT SIZE		-0.51***	-0.43***	-0.46***	-0.46***
LN AGE	-0.33***	-0.33***			
W_LN AGE		0.09*	-0.06	0.05	-0.05
LN AGE_*1*			-0.25***	-0.25***	-0.24***
LN AGE_*2*			-0.38***	-0.38***	-0.37***
LN AGE_*3*			-0.42***	-0.42***	-0.42***
Fixed effect_1			-0.34***	-0.35***	-0.64***
Fixed effect_2			-0.13	-0.13	-0.22
d_Ordinary house	0.07***	0.12***	0.10***	0.13***	0.09***
d_If added floor space	0.07***	0.07***	0.06***	0.06***	0.04**
d_Noise	-0.22**	-0.23**	-0.21**	-0.17**	-0.09
d_Construction error	-0.001	-0.03	-0.03	-0.05	-0.04
d_Moisture	-0.14	-0.12	-0.13	-0.14	-0.16*
d_Difficult lot	-0.42	-0.46	-0.49	-0.46	-0.40
d_Renovation object	-0.38	-0.48	-0.50	-0.43	-0.37
d_Radon	-0.008	-0.03	-0.05	-0.03	-0.07
d_No maintenance	-0.002	-0.06	-0.05	-0.13	-0.14
d_Historically important	0.41	0.33	0.27	0.23	0.27
d_Local part	0.35	0.34	0.42	0.45	0.25
d_Less than 50,000 SEK	0.32***	0.29***	0.27***	0.21***	0.20***
d_Other annotations	0.10	-0.10	0.09	0.08	0.06
d_Municip. water, own WC	0.03	-0.02	-0.02	-0.11***	-0.11***
d_Own water, municip. WC	-0.20***	-0.11	-0.09	-0.18**	-0.23***
d_Own water and WC	-0.11***	-0.13***	-0.13***	-0.22***	-0.25***
d_Municip, summer water WC	0.46	0.44	0.31	0.34	0.24
d_Own, summer water WC	-0.26	-0.30*	-0.34**	-0.39***	-0.40***
d_Own summer water, no WC	0.79***	0.75***	0.70**	0.64***	0.65***
d_No water, municip. WC	0.40	0.48	0.53	0.41	0.46
d_No water, own WC	0.12	-0.002	0.08	0.07	-0.09
d_No water or WC	-0.92***	-1.05***	-1.11***	-1.03***	-1.09***
d_Standars points (16–20)	0.15	0.19**	0.19**	0.21**	0.21**
d_Standard points (21–25)	0.33***	0.38***	0.37***	0.38***	0.38***
d_Standard points (26–30)	0.48***	0.52***	0.51***	0.51***	0.50***
d_Standard points (31–35)	0.56***	0.61***	0.58***	0.58***	0.57***
d_Standard points (36–45)	0.66***	0.71***	0.70***	0.69***	0.66***
d_Standard points (46–52)	0.83***	0.91***	0.98***	0.99***	0.96***
NET MIGRATION	0.0009***	0.0008***	0.0005***	0.0006***	0.001***
LN UNEMP/POP	0.04	0.06	0.08*	0.10*	-0.02
INTEREST RATE, 2 YEARS	-0.02**	-0.02**	-0.02**	-0.02***	-0.03***
MUNICIPALITY TAX	0.13***	0.06***	0.03*	0.03*	0.16***
AVERAGE INCOME	0.03***	0.02***	0.02***	0.02***	0.03***
d_Beach	0.15***	0.15***	0.16***	0.16***	0.17***
d_Near beach	0.01	0.01	0.02	0.02	0.01
d_Built–up area	0.21***	0.19***	0.17***	0.16***	0.16***
d_Västernorrland	0.03*	0.05**	0.02	0.02	0.13
GRAVITY	0.002***	0.0003			
W_GRAVITY		0.002***	0.005	0.003***	0.004***
GRAVITY_*1*			-0.003***	-0.001***	-0.001
GRAVITY_*2*			0.003***	0.004***	0.002***
GRAVITY_*3*			0.008***	0.01***	0.007***
d_Within 5 km range of E*12*	0.27***	0.14***	0.17***	0.16***	0.11***
d_Within 5 km range of E*4*	0.20***	0.13***	0.16***	0.15***	0.13***
CATERGORY_1				0.09***	0.08(***)
CATERGORY_2				0.17***	0.15(***)
CATERGORY_3				0.21***	0.17(***)
R^2	0.65	0.67	0.69	0.68	0.70
R^2*-adj.*	0.64	0.67	0.69		
Sq.corr				0.69	0.67
SIG-SQ	0.17	0.16	0.15		
Observations/ Iterations	4538	4538	4538	4538	4538 / 9

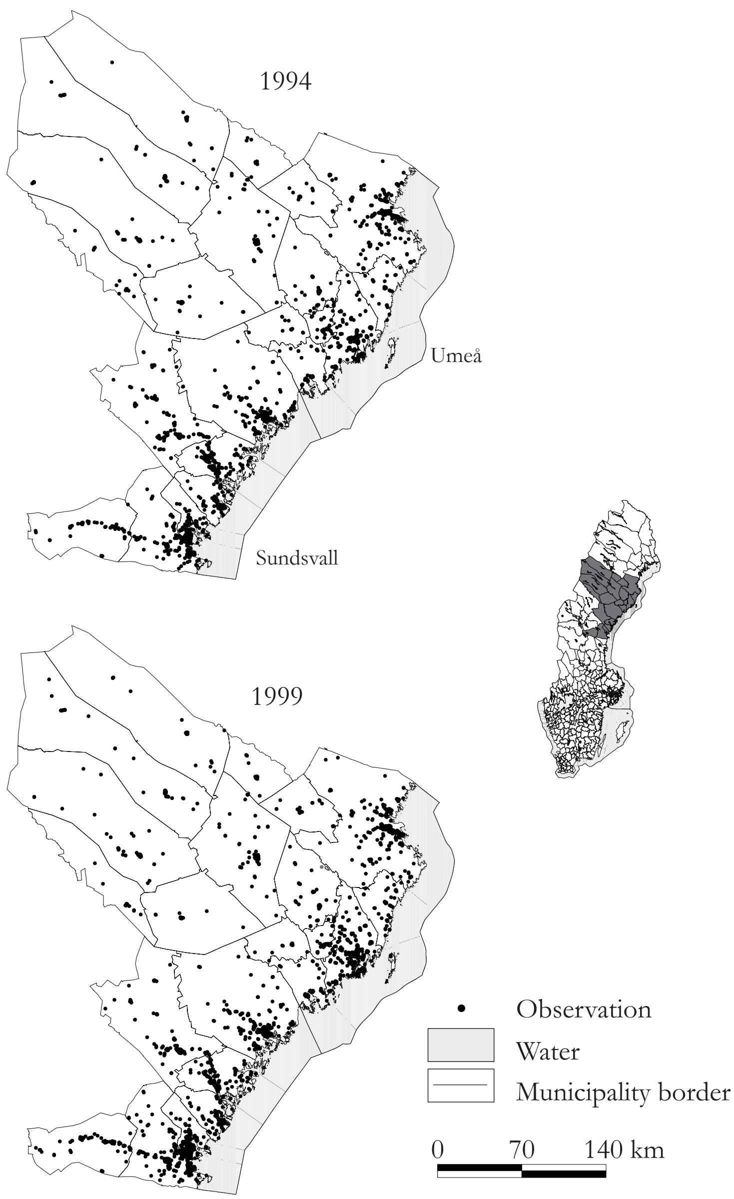

Figure 1: Single–Family Home Transactions in 1994 and 1999

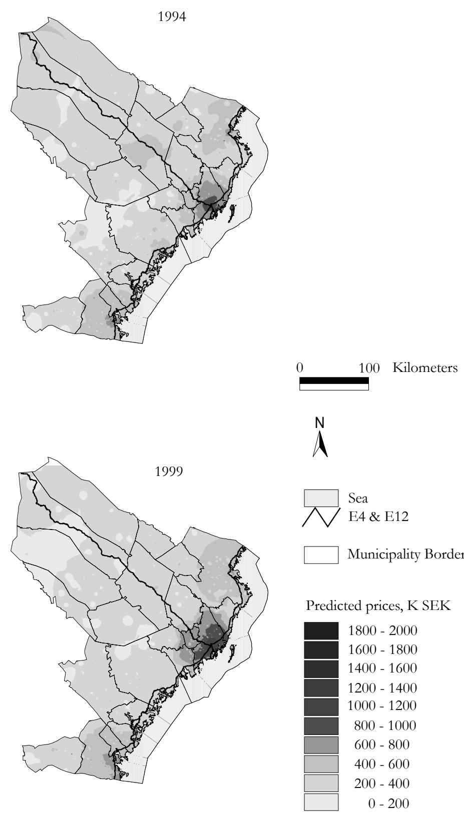

Figure 2: Single–Family Home Transactions in 1994 and 1999

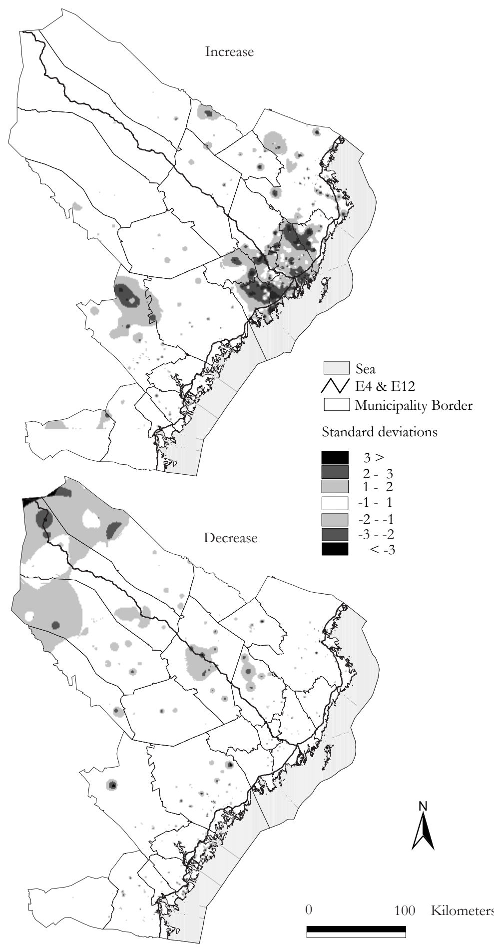

Figure 3: Price Prediction Differences between 1994 and 1999

Bibliography

[1] Andersson, R. 1998. *Attraktiva Städer - en samhällsekonomisk analys*. Byggforskningsrådet Svensk Byggtjänst, Stockholm.

[2] Anselin, L. 1988. *Spatial Econometrics: Methods and Models*. Kluwer Academic, Dordrecht.

[3] ———-. 1990. Spatial dependence and spatial structural instability in applied regression analysis. *Journal of Regional Science* 30: 185–207.

[4] ———-. Anselin, L. 2003. Spatial Externalities, Spatial Multipliers and Spatial Econometrics. *International Regional Science Review* Forthcoming.

[5] Basu, S., and T. G. Thibodeau. 1998. Analysis of Spatial Autocorrelation in House Prices. *Journal of Real Estate Finance and Economics* 17 (1).

[6] Beron, K., J. Murdoch, and M. Thayer. 2001. The Benefits of Visibility Improvement: New Evidence from the Los Angeles Metropolitan Area. *Journal of Real Estate Finance and Economics* 22 (2/3).

[7] Benson, E. D., J. L. Hansen, A. L. Schwatz Jr., and G. T. Smersh 1998. Pricing Residential Amenities: The Value of a View. *Journal of Real Estate Finance and Economics* 16 (1).

[8] Blomquist, G. C. 1998. Valuing Urban Lakeview Amenities Using Implicit and Contingent Markets. *Urban Studies* 25: 333–340.

[9] Blomquist, G. C., M. C. Berger, and J. P. Hoehn. 1998 New Estimates of Quality of Life in Urban Areas. *The American Economic Review* 78 (1): 89–107.

[10] Bodson, P., and D. Peeters. 1975. Estimation of the coefficients of a linear

regression in the presence of spatial autocorrelation. An application to a Belgian labour-demand function. *Environment and Planning A* 7: 455–472.

[11] Bogart, W. T., and B. A. Cromwell. 2000. How Much Is a Neighborhood School Worth? *Journal of Urban Economics* 47 (2000): 280-305.

[12] Bond, M. T., V. L. Seiler., and M. J. Seiler. 2002. Residential Real Estate Prices: A Room vith a View. *Journal of Real Estate Research* 23 (1/2): 129–137.

[13] Brasington, D. M. 1999. Which Measures of School Quality Does the Housing Market Value? *Journal of Real Estate Research* 18 (3): 395–413.

[14] Can, Y. 1992. Specification and estimation of hedonic housing price models. *Regional Science* 22: 453–474.

[15] Can, A., and I. Megbolugbe. 1997. Spatial Dependence and House Price Index Construction. *Journal of Real Estate Finance and Economics* 14 (2).

[16] Cheshire, P., and S. Sheppard. 1995. On the Prise of Land and the value of Amenities. *Economica* 62: 247–267.

[17] Clark, D. E., and T. Allison. 1999. Spent Nuclear Fuel and Residential Property Values: The Influence of Proximity, Visual Cues and Public Information. *Papers in Regional Science* 78: 403–421.

[18] Cliff, A., and K. Ord. 1972. Testing for Spatial Autocorrelation Among Regression Residuals. *Geographical Analysis* 4: 267–284.

[19] ———-. 1973. *Spatial Autocorrelation*. Pion Limited, London.

[20] Des Rosiers, F., M. Thériault, Y. Kestens, and P. Villeneuve. 2002. Landscaping and House Values: An Empirical Investigation. *Journal of Real Estate Research* 23 (1/2): 139–161.

[21] Englund, P., J. M. Quigley, and C. L. Redfearn. 1998. Improved Price Indexes for Real Estate: Measuring the Cource of Swedish Housing Prices. *Journal of Urban Economics* 44: 171–196.

[22] Florax R. J. G. M., and H. Folmer. 1992. Specification and Estimation of of Spatial Linear Regression Models: Monte Carlo Evaluation of Pre–test Estimators. *Regional Science and Urban Economics* 22: 405–432.

[23] Haas, G. C. 1922. *A Statistical Analysis of Farm Sales in Blue Earth County, Minnesota, as a Basis for Farm Land Appraisal* Master Thesis, The Univesity of Minnesota.

[24] Kelejian, H. H., and I. R. Prucha. 1999. A Generalized Moments Estimator for the Autoregressive Parameter in a Spatial Model. *International Economic Review* 40 (2): 509–533.

[25] Lancaster, K. 1966. A new approach to consumer theory. *Journal of Political Economy* 74: 132–157.

[26] Lindgren, P., and G. Rosberg. 1992. *Vem bor till vilket pris?*. Boverket, Karlskona.

[27] Pace, R. K., and O. W. Gilley. 1997. Using the Spatial Configuration of the Data to Improve Estimation. *Journal of Real Estate Finance and Economics* 14 (3).

[28] Rosen, S. 1974 Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy* 34–55.

[29] Shultz, S. D., and D. A. King. 2001. The Use of Census Data for Hedonic Price Estimation of Open Space Amenities and Land Use. *Journal of Real Estate Finance and Economics* 22 (2/3).

[30] Sinivitanidou, R. 1996 Do Office-Commercial Firms Value Access to Service Employment Centers? A Hedonic Value Analysis within Polycentric Los Angeles. *Journal of Urban Economics* 40: 125–149.

[31] Smersh, G. T., and Marc T. Smith. 2000. Accessibility Changes and Urban House Price Appreciation: A Constrained Optimization Approach to Determining Distance Effects. *Journal of Housing Economics* 9: 187–196.

[32] Thompson, B., and M. Hills. 1999. Wired Up for Extra Value. *Journal of Real Estate Research* 17 (1/2): 245–255.

[33] Tse, R. Y. C. 2002. Estimating Neighborhood Effects in House Prices: Towards a New Hedonic Model Approach. *Urban Studies* 39 (7): 1165–1180.

[34] Wigren, R. 1987. House Prices in Sweden: The Significance of Attributes. *Scandinavian Housing and Planning Research* 4: 243–261.