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# On Space–Time Changes of Hedonic Prices for Single Family Houses

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**Abstract:** In this paper the hedonic prices for single-family houses in two Swedish counties, for the years 1994 and 1999, are compared. Structural and neighborhood characteristics together with accessibility measures are used as attributes in the hedonic price functions. Influenced by spatial dependence, the hedonic prices are estimated by Spatial Autoregressive Bootstrap. Heterogeneity plays an important role in this paper for a couple of attributes. Apart from the two county capitals other municipality centres are found to influence the prices at different magnitude geographically. The importance of attributes changes over space and time.

**Keywords:** Hedonic prices, Single family houses, SAR–Bootstrap, Heterogeneity, Spatial dependence

**Classification (JEL):** D46, D61, R20, R21

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## INTRODUCTION

The value of and the attributes of public and private real estate develops through dynamic processes involving actors on both the supply and demand side. City managers, at least in theory, may want to improve the supply to maximize the utility of its inhabitants. But if the supply does not fit the utility driven demand for housing by households or the profit driven demand for nonresidential space by firms, the value of the property and the attractiveness of the city, or region, is set under pressure by competition from other cities or from other parts within the city. In the current movement of the economy towards a knowledge based society this competition for movable labour by supply of “attractiveness” has been even more emphasized. Hence, the supply side clearly has an interest in the valuation at the demand side of the attributes associated with its real estate.

The aim of this paper is to investigate and develop appropriate statistical tools, to determine and quantify the valuation of housing attributes of single family houses in two Swedish counties. This is done using hedonic price theory and spatial econometrics.

The basis for the theory of hedonic prices lies in the assumption that a good can be seen as a bundle of characteristics matching the household's utility function, as formulated in Lancaster (1966). It is assumed that the buyer implicitly reveals his or her preferences and valuation of the attributes through the price paid. Since each house is purchased by the highest bidding household it is assumed that the market prices give the outer envelope of the valuation of each attribute by all households in the market. This means that the attractiveness of a region, of areas within the region, and of individual residential and nonresidential units can be measured through the valuation of the attributes associated with the supply.

The empirical literature on hedonic prices for single-family houses is numerous but to a large extent, e.g. Blomquist et al. (1998) and Sinivatanidou (1996) based on American data. Among the exceptions are Wigren (1987), Englund et al. (1998), and Cheshire and Sheppard (1995) using Swedish and British data respectively. The distance to the Central Business District (CBD), high level of service and waterfront location influences the price in a positive way according to a number of Swedish qualitative studies, e.g. Lindgren and Rosberg (1992), and Andersson (1998). Others have studied the problem with a focus on quantification, e.g. Archer et al. (1996) and Andersson (1997). Heikilla (1989) question the concepts of a monocentric impact on

the price structure and argue that cities may have polycentric structures and uses Los Angeles as an example.

A common feature among hedonic price studies are their interest to examine some specific characteristic and its influence on prices for single-family houses. To name but a few, the presence of lake view in Blomquist (1998), the impact of nearby power lines in Colwell (1990), and the introduction of casinos in Buck et al. (1991). Bogart and Cromwell (2000) study the impact of a re-distribution of schools on housing values.

The next section treats the theory of hedonic prices and spatial econometrics. This is followed by a description of data and the attributes. The empirical examination is outlined in the forth 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 house, may be described by  $m$  characteristics. Each house is then represented by the vector  $\mathbf{z} = (z_1, \dots, z_m)$ . An element  $z_i$  measures the amount of the  $i$ th characteristic embedded in each house. The price function based on this vector of characteristics is the hedonic price function  $p(\mathbf{z}) = p(z_1, \dots, z_m)$ .

Household preferences are represented by the utility function:

$$U = u(\mathbf{z}, \mathbf{y}, \boldsymbol{\alpha}) \quad (1)$$

where  $\mathbf{z}$  is consumption of the single family house,  $\mathbf{y}$  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 house 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's bid rent function:

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

and implicitly:

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

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 house when characteristic  $i$  increases, while keeping other levels constant.

**Problem (MAX CoF)** *The household chooses a single family house with characteristics  $\mathbf{z}$ , and its consumption of the composite good  $\mathbf{y}$  by solving:*

$$\begin{aligned} \max_{\mathbf{z}, \mathbf{y}} \quad & u(\mathbf{z}, \mathbf{y}, \boldsymbol{\alpha}) \\ \text{s.t.} \quad & M \geq p(\mathbf{z}) + \mathbf{y} \end{aligned} \quad (4)$$

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

Through the first order conditions we get:

$$\frac{u_i}{u_y} = p_i \quad \forall i \quad (5)$$

where  $u_i = \frac{\partial u}{\partial z_i}$ ,  $u_y = \frac{\partial u}{\partial \mathbf{y}}$ , 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 household's optimal choice of a single family house is characterized by equality between the slope of the bid rent and the hedonic price with respect to each characteristic:

$$\frac{\partial \gamma}{\partial z_i} = \frac{\partial \mathbf{y}}{\partial z_i} = p_i \quad \forall i \quad (6)$$

Assuming optimizing behavior, (6) indicates that if we are able to estimate the hedonic price for a characteristic, then this observation provides local information about the household's preferences or willingness to pay for the attribute in the vicinity of the observed choice. Hence, this justifies the use of the hedonic price approach in the analysis of the market for single family houses when the mix of attributes is developed not far away from the current market situation.

The vector  $\mathbf{z}$  consists as mentioned of a set of characteristics which subjectively are determined by the household. This vector of characteristics is often divided into three broader groups, structural ( $\mathbf{s}$ ), neighborhood ( $\mathbf{n}$ ), and accessibility ( $\mathbf{a}$ ) attributes with  $\boldsymbol{\beta}$ ,  $\boldsymbol{\eta}$ , and  $\boldsymbol{\psi}$  as the corresponding parameter vectors. Given this, the hedonic

price function of a general regression model can be formulated as:

$$p(\mathbf{z}) = f(\mathbf{s}, \mathbf{n}, \mathbf{a}, \boldsymbol{\beta}, \boldsymbol{\eta}, \boldsymbol{\psi}) + \varepsilon \quad (7)$$

Before we move to the estimation part, the possibility of spatial dependence, or spatial autocorrelation, in the material must be considered. In other words, there might be some inherent systematic dependence between the observations unexplained by traditional variables. Two types of spatial dependence are tested for in this paper.

The first type, is present if spatial correlation in the dependent variable between observations exists. This means that the transaction price on one single family house is influenced by the prices for nearby house transactions and vice versa, cf. Anselin (1988) and Can (1992). If ignored, the OLS estimates will be biased and lead to incorrect inference. The spatial dependence problem is solved by adding a spatial lag to (7):

$$p(\mathbf{z}) = \rho \mathbf{W} p(\mathbf{z}) + f(\mathbf{s}, \mathbf{n}, \mathbf{a}, \boldsymbol{\beta}, \boldsymbol{\eta}, \boldsymbol{\psi}) + \varepsilon \quad (8)$$

where  $\rho$  is an autoregressive coefficient.  $\mathbf{W}$ , with elements  $w_{rs}$  corresponding to observation pair  $r$  and  $s$ , is the generalized weight matrix, and  $\mathbf{W}p(\mathbf{z})$  is the spatially lagged dependent variable.

The second type, arises when the error term of an observation is correlated with the error terms of observations located nearby i.e. lack of stochastic independence between observations. This was brought to public attention by among others Cliff and Ord (1972) and Bodson et al. (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. The spatial dependence is incorporated in (7) via an autoregressive error term:

$$\begin{aligned} p(\mathbf{z}) &= f(\mathbf{s}, \mathbf{n}, \mathbf{a}, \boldsymbol{\beta}, \boldsymbol{\eta}, \boldsymbol{\psi}) + \varepsilon \\ \varepsilon &= \lambda \mathbf{W} \varepsilon + \boldsymbol{\xi} \end{aligned} \quad (9)$$

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

In both cases the autoregressive coefficients are usually unknown and must therefore be estimated jointly with the regression coefficients.

The Moran's I test is commonly used to test for the presence of spatial autocor-

relation. To complement and validate the Moran's I test results other test can be used such as the G-I\* statistic for spatial association by Ord and Getis (1995), and Local Moran's I by (Anselin (1995b).

Another important issue analyzed in this paper are problems of heterogeneity, or structural regimes, present in the data. That means that attributes are valued differently in some part of the geographical area. If not acknowledged, the variables may be ruled out as insignificant or averaged out causing us to miss important information on hot/cold spots. This will be analysed further later in this paper.

## ATTRIBUTES OF THE REALIZED SALES OF SINGLE FAMILY HOUSES 1994 AND 1999

This problem is applied to the market for single family houses in the two counties, Västernorrland and Västerbotten, in the northern part of Sweden for two years, 1994 and 1999. In 1994 Västernorrland had 261,000 inhabitants and 252,000 in 1999 divided over 7 municipalities. Despite that the county of Västerbotten is geographically larger and have 15 municipalities, the population is almost the same, 258,200 in 1994 and 257,800 in 1999. During the study period all municipalities except largest municipality, Umeå, has faced a decrease in population. It has had a population increase, from 97,000 in 1994 to 104,000 in 1999.

The data set consists of 2,778 observations on realized sales of single family houses in 1994 and 4,538 for the year 1999 distributed on the 22 municipalities in two counties. The geographic dispersion is presented in Figure 1 indicated by dots.

The spatial distribution of the realized sales between the two years is rather similar. Most transactions takes place along the coast, and especially in the regional centres, Umeå (the cluster west of the small island) and Sundsvall (the south east cluster). A more closely look at the maps displays the locations of inland roads.

Before the econometric part of the paper is outlined, it is appropriate to look at some descriptive statistics and to discuss the expected variable signs. Variables that lack data for some of the variables are indicated by a (-) in Table 1.

Two dependent variables LN LOT SIZE and LN PRICE, the logarithm of the lot size and price respectively, are to be estimated in this paper. The motivation for this division is discussed in the next section.



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

The first group consists of the structural variables treating the characteristics specific for the single family house. Obvious attributes to be included are the floor size and the age of the house. The former are expected to have a positive impact on LN LOT SIZE while the latter is expected to influence LN LOT SIZE positively, but LN PRICE negatively. Specific annotations about the lot or the house are accounted for for some of the observations. They are treated as dummies and ought to have negative/positive signs for bad/good attributes. Another set of dummies concerns the water supply. The default is here chosen to be water and wc supplied by the municipality. This is the most common, over 80 percent for both years. Other kinds of water supply ought to have negative signs because of the extra time that you have to spend on maintenance for instance. It could also be an indicator of water quality. To determine how much real estate tax to pay, each single family house is officially graded using a system of standard points. In this paper they are divided in six groups and given the value one if they fall within a group. All standard point dummies are expected to have positive signs. They are measured against the lowest group that includes the values 0–15. The origin of the buyer is interesting. For most of the transactions, information about the adress of the buyer at the time of purchase is available. To test if the buyers origin is important a dummy variable is given the value 1 if the buyer comes from a municipality outside the one where the single family house lies. This is the case for only 5 percent of the transactions in 1994 and 9 percent in 1999. This gives us some indication on how the real estate market is functioning in the two counties. The sign is diffucult to speculate on, but if one expect the buyer to be more careful in the search for a house when the distance from the present home increases, a negative sign is what to expect. This would mean that the buyer has a greater knowledge about the real estate market. For some cases the origin of the buyer was unavailable. These are therefore put together in the other buyer–origin dummy. This is expected to be unsignificant. Other structural variables are dummies whether the single family house is an ordinary house (86 percent for both years) in contrast to semidetached houses or houses linked by a garage which are on average smaller. The sign is expected to be positive. If the house has been altered during its lifetime, then value should increase and a positive sign is expected. The last and perhaps most difficult structural attribute variable is the residual lot size. This variable consists of the residuals from the LN LOT SIZE estimation. When the lot size is larger, *ceteris paribus*, than expected for a typical

lot, the price should be higher. The variable should therefore have a positive sign.

The second group are the attributes that treats the neighborhood surrounding the single family houses. 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. On the other hand, the size of the population is expected to have a negative impact on the lot size since higher demand for land drives up the prices making the lots more expensive to purchase. Adjustments of the lot sizes are one alternative to keep the prices at a reasonable level in more densely populated areas. To investigate the importance of a functioning labour market  $\text{LN UNEMPLOYED/POPULATION}$  is included. A high quota means that a high degree of unemployed drives the prices downwards. Higher interest rates makes it more expensive to borrow money, and increases the risk in connection with a purchase. The sign is therefore expected to be negative. The municipality tax is difficult to predict. The average municipality tax is 20.17 percent in 1994 and has increased to 22.41 percent five years later. A higher level could be an indication of better public service but it could also be an indication of financial strains on the municipality. The sign is nonetheless expected to be positive as an indication of a high level of public service. The average income level for people over 20 years of age has increased by almost 30,000 SEK in real values between 1994 and 1999. The spread between the municipalities is also bigger in 1999. The variable is included to reflect the economic situation in the municipality and the sign ought to be positive. For houses lying at the beach or near the beach, a positive sign is expected due to the presence of the water front location. In 1994, 77 percent of the transactions were transactions of houses lying in build-up areas. This figure has increased to 81 percent in 1999. The sign is expected to be positive. To investigate if there are differences between the two counties a dummy for the county of Västernorrland was included. The sign is unpredictable.

The third group are the accessibility attributes. As was the case for the population variable, the variable  $\text{LN DEC}$  is included in the estimation of the  $\text{LN LOT SIZE}$ . A higher distance from the CBD is expected to increase the size of the lot. This variable is not included in the estimation of the  $\text{LN P}$  due to collinearity problems. Instead a combination of distance and population was used, defined as:

$$\text{GRAVITY} = \sum_1^{22} \frac{\text{POP}_j}{D_{ij}} \quad (10)$$

the sum of quotients of population in each of the 22 municipalities divided by the distances (crow distance) between the observation  $i$  and each municipality CBD  $j$ . This implies that a distance is valued differently depending on the surrounding population size. A high population in the vicinity drives up the price, and less if it lies further away. If this is correct, a positive sign is what to expect. The last two accessibility attributes are two dummy variables, indicating whether a house lies within a 5 km range of one of the two European roads E4 and E12. This means good communications and closeness to clustering and should affect the prices in a positive way.

## THE EMPIRICAL EXAMINATION

In order to test whether spatial dependence exist in the data set the test statistics Moran's  $I$  and  $G-I^*$  were used. It was decided to use a matrix that consisted of the row standardized inverse distances between observations with a distance cut-off at 48 km, the minimum allowable distance between observations in the 1994 data set, so that all observations has at least one neighbor. For comparability between data sets the same distance cut-off was used for the 1999 data set. The results from the Moran's  $I$  tests are found in Table 2 for both dependent variables.

These tests indicate positive spatial autocorrelation for both of the dependent variables. The dependence is highest for LN PRICE. This spatial weight matrix was also used in the calculations of the  $G-I^*$  statistics. Based on these tests complemented with Moran Scatterplots and LISA maps (available upon request) these weight matrices were chosen for the subsequent analysis. The maps indicates hot spots in the two regional centers Umeå and Sundsvall surrounded by a suburban ring of less expensive single family houses. Minor clusters of high values are found at the other municipality centers along the coast.

These hot spot leads us to another important question. Are there heterogeneity present in the data? That is, the same attribute is valued differently at different locations. The data was, for some variables (LN DEC, LN BEF, LN AGE, and GRAVITY) divided into three groups. The first group consists of the two regional centres, the second of other coastal municipalities and, thirdly, inland municipalities. They 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 houses using a spatial Chow–Wald test, see Anselin (1990).

The estimation of the hedonic prices  $\text{LN PRICE}$  consists of two steps. Firstly, an estimation of the lot size  $\text{LN LOTSIZE}$  and secondly, an estimation of the price equation.

Since the lot size is determined by many variables determining the price multicollinearity is a problem. In order to normalize the lot size effect, the residuals from the estimation of  $\text{LN LOTSIZE}$  are instead used in the estimation of  $\text{LN PRICE}$ .

As the price for land falls when distance increases from the CBD due to the increased supply, the lot size can be larger for the same amount of money. So the  $\text{LN DEC}$  should have a positive sign. Age is also a factor that should be influential. The hypothesis is that older lots are larger than newer ones. To acknowledge the difference in demand, the municipality population is included. The house type should be important. The data set includes three types of single family houses, ordinary house, semidetached, or houses linked by a garage. The dummy for an ordinary house is used here. The floor space is expected to have a positive sign. Four dummies for specific location specifics are included, the two beach dummies, the dummy for built-up area location and finally the Västernorrland dummy. The results from this first regression is presented in Table 3.

The results for both years are in line with what to expect. The distance plays an important role, especially for the two major municipalities. The lots are larger further away from the CBD. An increased population decreases the lot size. Older lots are in general larger.

To analyze if, and in that case the kind of spatial dependence that exists for the lot size, Lagrange Multiplier tests were used. For the year 1994 it was suggested to implement a spatial lag, and for 1999 an error correction. In data sets, such as the 1994, with heteroscedasticity and where the assumption of normality is rejected, a Spatial Bootstrap model is a good choice, Freedman and Peters (1984a, 1984b) and Anselin (1988, 1990b, 1995a).

For the 1994 data set the autoregressive parameter  $\rho$  is positive and significant indicating positive spatial dependence.

For the 1999 data set, a Spatial Autoregressive Generalized Moments (SAR-GM) model Kelejian and Prucha (1999) was used, considering the non-normality and group-wise heteroscedasticity in three categories (same as the heterogeneity grouping). The variable  $\text{LN BEF}_3$  is no longer significant for 1999 but instead the  $\text{NEAR BEACH}$  is. The autoregressive parameter  $\lambda$  is positive for 1999, thus the error terms in locations nearby tend to coincide more than purely by chance.

The residuals from the lot size estimations are then included in the price equation

as an independent variable to be estimated for LN PRICE. The results from the price estimations are presented in Table 4.

The Lagrange Multiplier tests indicates that both OLS regressions needs an additional spatial lag. Both the data from 1994 and 1999 were then estimated by Spatial Autoregressive Bootstrap. The  $R^2$  is 0.78 in 1994 and slightly higher (0.83) in 1999. The autoregressive parameter  $\rho$  is also higher in 1999 (0.737).

The LN AGE variables are as expected negative and significant for all three classes. People living in Umeå and Sundsvall are less restrictive about the age than people living in other municipalities. If the buyer does not live in the municipality where the observation lies, then the price goes down, an indication that buyer is more restrictive in his/her purchase. This impact is lower in 1999. The residual lot size is as expected positive. The same applies for the municipality tax. The GRAVITY variables are all positive and significant. Observations lying in class 1 have the lowest values and has also deceased over time. The income variable is positive and significant in 1994 but not in 1999. Closeness to the European roads are perceived to be positive, but the importance is smaller in 1999. The interest rates are only important in 1999. Higher rates leads to lower prices. For the annotations, it is only NO MAINTENANCE that is negative and significant in 1994. In 1999 in case a house that is officially valued less than 50,000 SEK, the price is influenced in a positive way! Supply of water and wc other than from municipality is perceived as negative, and more so in 1999. All of the standard point dummy variables are shown to be important. The importance increases with the number of points. The importance have decreased though between 1994 and 1999 except for the highest standard points group.

To illustrate the predicted values for LN PRICE across the counties two smoothing maps, one for each year, are presented in Figure 2. The reader can clearly detect the concentration of high values around the two regional centers and in the other coastal municipalities. Lower prices are found in the inland and again higher in the mountain area in the north west.

It is also interesting to compare these two figures to investigate the development over time in the real estate market. The difference in prices between the two years are illustrated a new smoothing map Figure 3 as standard deviations from the mean difference which is an 5,700 SEK increase from 1994 to 1999. The darker grey areas has had a significant price increase during this time period. This is particularly noticable in the Umeå region. This regional influence is expanding. Increase prices are also found in the Sundsvall region, and at three clusters west and north of Umeå. The lighter grey

areas has had a significant decrease in prices on single family houses between 1994 and 1999. This is noticable along the European road E12 going west from Umeå, and in the inlands west of Sundsvall.

## CONCLUSIONS

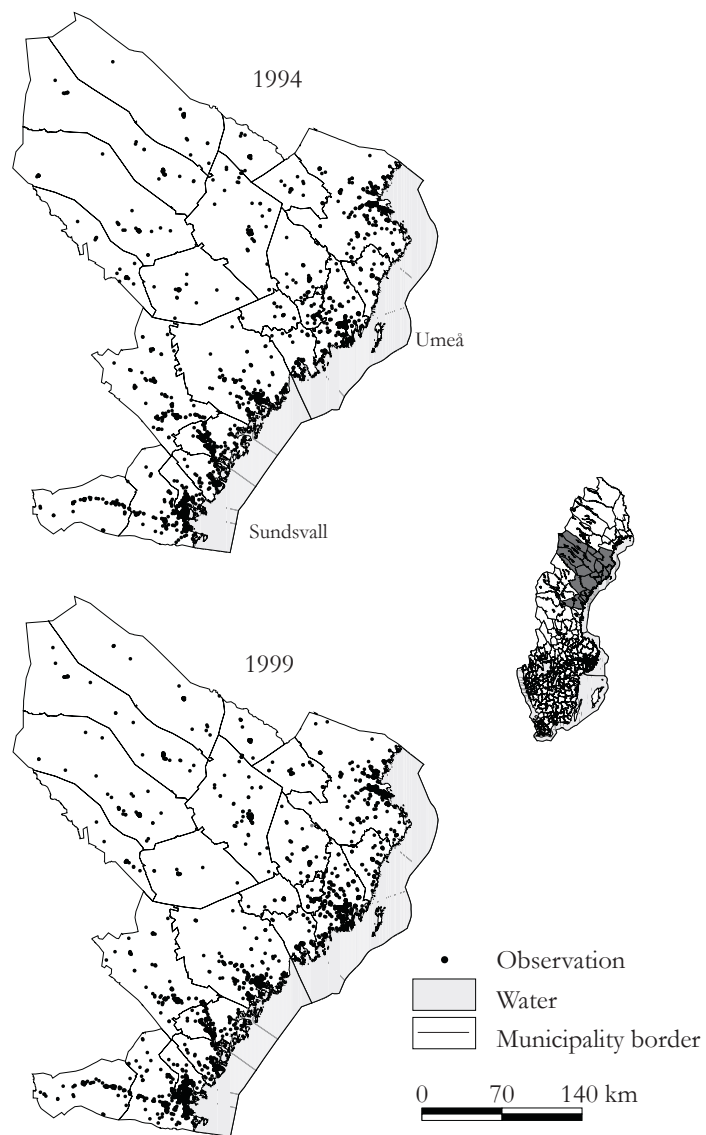
The purpose of this paper was to use hedonic price theory to assess the important attributes for the price determination of single family houses in two Swedish counties for the years 1994 and 1999. Great effort was put on detecting and treating the problems of spatial dependence. The econometric analysis was divided into two parts. First an estimation of the LN LOTSIZE to acknowledge multicollinearity between some of the variables important in the both models. The second part consisted of the LN PRICE estimation. This was done using Spatial Autoregressive Bootstrap to treat the present lag dependence and heteroscedasticity. This was especially strong for the year 1999.

Important attributes for the determination of the lot size was distance to the municipality CBD. This was most important for lots lying in the two regional centres. A large population implies smaller lots. A good indicator for the size is also how old the house is.

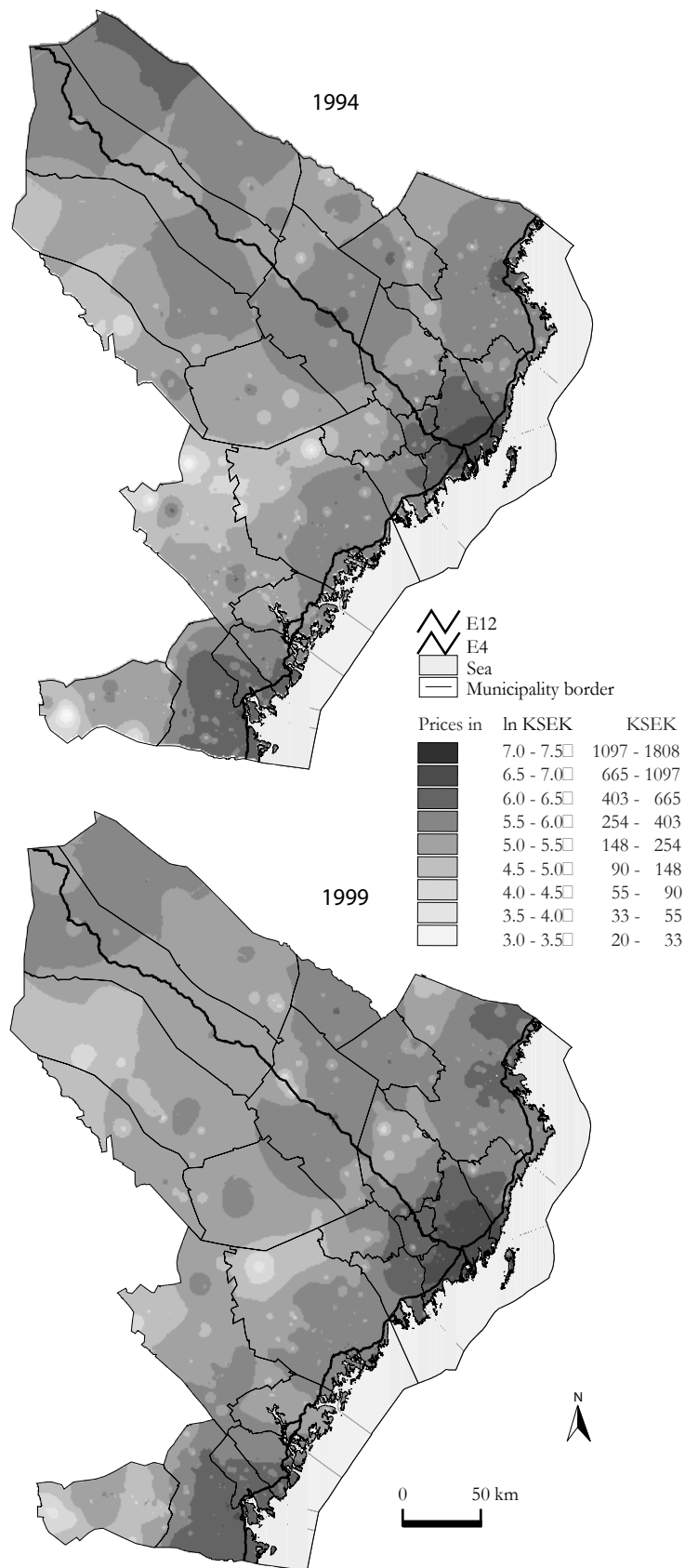
For the estimation of LN PRICE the age is once again important and was divided in three classes. Houses lying in the inland part is most sensitive to age. The combined variable GRAVITY consisting of population divided by the distance to municipality centers is positive, and have the smallest parameter value for the large municipalities. It is also positive to live in a build-up neighborhood and preferably within reach of one of the two european roads.

To illustrate the results three maps were presented. The Umeå region has had a increase in prices on single family houses between 1994 and 1999, an indication of regional expansion.

## FIGURES AND TABLES

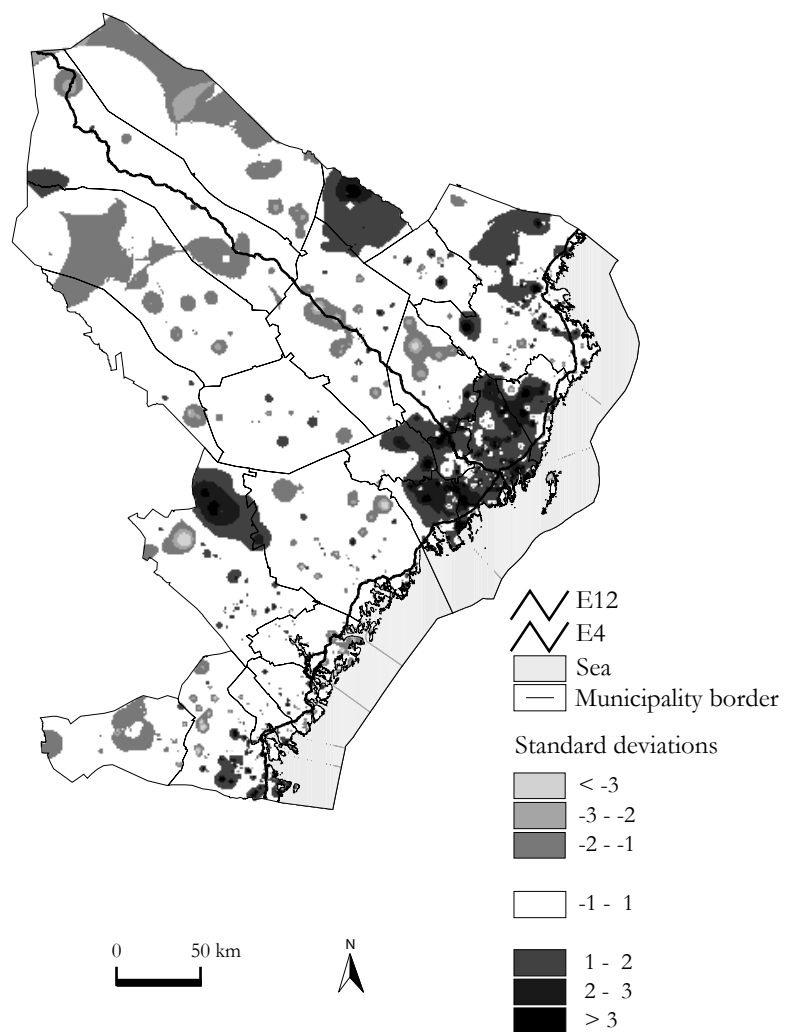


**Figure 1:** Single Family House Transactions in 1994 and 1999



**Figure 2:** Prediction of Prices in 1994 and 1999





**Figure 3:** Price Prediction Differences between 1994 and 1999

**Table 1:** The Descriptive Statistics for the years 1994 and 1999

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 LOTSIZE	ln m <sup>2</sup>	7.06(0.86)	4.36–11.28	6.99(0.78)	4.36–10.72	
LN FLOORSIZE	ln m <sup>2</sup>	4.80(0.35)	3.22–6.07	4.85(0.28)	3.64–6.55	(+)
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	(+)
<50,000	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	(-)
Buyer not in same municip.	dummy	0.05(0.22)	0–1	0.09(0.28)	0–1	(?)
Buyers location unknown	dummy	0.03(0.17)	0–1	0.008(0.09)	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	(+)
Residual LN LOT SIZE	residuals	-0.004(0.54)	-2.21–3.48	-0.004(0.50)	-2.67–2.97	(+)
Netmigration	persons	207.1(500.2)	-176–1321	-150.75(155.2)	-347–100	(?)
LN POPULATION	ln pop.	10.6(0.98)	7.9–11.5	10.7(1.01)	7.92–11.55	(+)
ln (Unemployed/Population)	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	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	(?)
LN DEC	ln m	8.61(1.30)	4.36–11.72	8.47(1.25)	3.59–11.81	(-)
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:** Moran's I test for Spatial Autocorrelation in the Single Family House Market in 1994 and 1999. (empirical pseudo-significance based on 999 random permutations)

Variable	I	Mean	St.Dev	Prob
LN P_1994	0.41	0.00	0.006	0.001
LN P_1999	0.44	0.00	0.004	0.001
LN LOTSIZE_1994	0.29	0.00	0.006	0.001
LN LOTSIZE_1994	0.23	0.00	0.004	0.001

**Table 3:** Regression Results for LN LOTSIZE. \* indicates insignificant values at 5 percent level

Variable	OLS_1994	OLS_1999	SAR-BOOT_1994	SAR-GM_1999
$\rho$			0.343	
$\lambda$				0.721
<i>Constant</i>	5.032	4.426	2.791	4.364
LN DEC_1	0.181	0.208	0.133	0.247
LN DEC_2	0.111	0.081	0.077	0.110
LN DEC_3	0.059	0.066	0.039	0.085
LN POP_1	-0.167	-0.167	-0.124	-0.190
LN POP_2	-0.109	-0.066	0.082	-0.084
LN POP_3	-0.078	-0.060	-0.065	-0.059*
LN AGE	0.254	0.237	0.228	0.242
LN FLOORSIZE	0.179	0.289	0.187	0.300
<i>d_Ordinary house</i>	1.135	1.031	1.009	0.950
<i>d_Beach</i>	0.560	0.293	0.541	0.284
<i>d_Near Beach</i>	-0.058*	0.133	-0.071*	0.127
<i>d_build up area</i>	-0.589	-0.645	-0.562	-0.632
<i>category_1</i>				0.221
<i>category_2</i>				0.218
<i>category_3</i>				0.245
$R^2$	0.60	0.60	0.61	0.60
$R^2$ -adj.	0.60	0.60		
<i>Sq.corr</i>			0.60	0.59
SIG-SQ	0.301	0.247	0.297	
<i>Observations</i>	2778	4538	2778	4538
<i>Replications/Iterations</i>			999	7

**Table 4:** The Regression Results for LN PRICE. \* indicates insignificant valus at 5 percent level.

Variable	OLS_1994	OLS_1999	SAR-BEOT_1994	SAR-BEOT_1999	1999-1994
$\rho$			0.458	0.737	0.279
Constant	-1.193	-1.269	-2.391	-1.188	1.203
LN FLOORSIZE	0.577	0.550	0.551	0.518	-0.033
LN AGE_1	-0.208	-0.269	-0.208	-0.243	-0.035
LN AGE_2	-0.290	-0.347	-0.225	-0.291	-0.066
LN AGE_3	-0.347	-0.371	-0.282	-0.299	-0.017
$d_{\text{Ordinary house}}$	0.080	0.121	0.084	0.109	0.025
$d_{\text{If added floor space}}$	0.097	0.062	0.078	0.031*	-0.047
$d_{\text{Noise}}$	0.117*	-0.109*	0.098*	-0.099*	-0.197
$d_{\text{No electricity}}$	-0.274*		-0.139*		
$d_{\text{Construction error}}$	-0.274*	-0.025*	-0.233*	-0.013*	0.220
$d_{\text{Moisture}}$		-0.140*		-0.143*	
$d_{\text{Difficult lot}}$	-0.086*	-0.490*	-0.079*	-0.414*	-0.335
$d_{\text{Renovation object}}$		-0.424*		-0.357*	
$d_{\text{Radon}}$		-0.038*		-0.069*	
$d_{\text{No maintenance}}$	-0.629	0.005*	-0.606	-0.031*	0.575
$d_{\text{Indor swimmingpool}}$	-0.210*		-0.208*		
$d_{\text{Historically important}}$		0.402*		0.368*	
$d_{\text{Local part}}$		0.414*		0.249*	
$d_{\text{<50,000}}$		0.271		0.234	
$d_{\text{Other annotations}}$	-0.073*	0.084*	-0.115*	0.071*	0.186
$d_{\text{Municip. water, own WC}}$	0.014*	-0.005*	-0.016*	-0.046	0.030
$d_{\text{Municip. water, no WC}}$	-0.211*		-0.138*		
$d_{\text{Own water, municip. WC}}$	0.002*	-0.160	0.004*	-0.068*	-0.072
$d_{\text{Own water and WC}}$	-0.085	-0.113	-0.094	-0.116	-0.022
$d_{\text{Own water, no WC}}$	-0.407	-0.314*	-0.414		
$d_{\text{Municip, summer water WC}}$		0.386*		0.354*	
$d_{\text{Own, summer water WC}}$	0.045*	-0.319	0.035*	-0.374	-0.409
$d_{\text{Own summer water, no WC}}$	0.058*	0.661	-0.012*	0.613	0.625
$d_{\text{No water, municip. WC}}$		0.450*		0.474*	
$d_{\text{No water, own WC}}$	-0.591	0.119*	-0.625	-0.004*	0.621
$d_{\text{No water or WC}}$	-0.335	-1.08	-0.384	-1.130	-0.746
$d_{\text{Buyer not in same municip.}}$	-0.300	-0.108	-0.266	-0.039	0.227
$d_{\text{Buyers location unknown}}$	0.001*	-0.157*	0.013*	-0.061*	-0.074
$d_{\text{Standars points 16-20}}$	0.343	0.105	0.285	0.205	-0.080
$d_{\text{Standard points 21-25}}$	0.586	0.280	0.518	0.385	-0.133
$d_{\text{Standard points 26-30}}$	0.759	0.421	0.684	0.502	-0.182
$d_{\text{Standard points 31-35}}$	0.811	0.502	0.729	0.574	-0.155
$d_{\text{Standard points 36-45}}$	0.884	0.604	0.797	0.673	-0.124
$d_{\text{Standard points 46-50(2)}}$	0.912	0.817	0.737	0.912	0.175
Residual lot size	0.134	0.124	0.119	0.109	-0.010
Netmigration	$3 \cdot 10^{-5}$ *	0.0005	$7 \cdot 10^{-6}$	$-3 \cdot 10^{-5}$	
$\ln \text{Unemp/Pop}$	-0.182	0.056*	-0.018*	0.033	0.051
Interest rate, 2 years	0.007*	-0.023	0.007*	-0.028	0.035
Municipality tax	0.082	0.087	0.010	0.036	0.026
Average income	0.013	0.019	0.005	-0.0002*	-0.0052
$d_{\text{beach}}$	0.341	0.200	0.364	0.208	-0.156
$d_{\text{Near beach}}$	0.081*	0.024*	0.071*	0.003*	-0.068
$d_{\text{build up area}}$	0.103	0.010	0.096	0.083	-0.013
$d_{\text{Västernorrland}}$	0.028*	-0.023*	0.082	0.016*	-0.066
GRAVITY_1	0.001	0.0007	0.001	0.0004	0.003
GRAVITY_2	0.004	0.005	0.003	0.003	0.000
GRAVITY_3	0.012	0.015	0.006	0.005	-0.001
Within 5 km range of E12	0.212	0.278	0.133	0.117	-0.016
Within 5 km range of E4	0.183	0.223	0.102	0.069	-0.033
$R^2$	0.73	0.67	0.78	0.83	
$R^2$ -adj.	0.73	0.67			
Sq.corr			0.72	0.66	
SIG-SQ	0.168	0.157	0.171	0.167	
Observations	2778	4538	2778	4538	
Replications			999	999	



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