Oktober 2001

Prices and constant quality price indexes for multi-dwelling and commercial buildings in Sweden*

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Abstract. The propose of this paper is to estimate constant quality price trends and analysing factors determining market prices for MDCBs (multi-dwelling and commercial buildings) in Sweden. We use high quality data for housing and municipality attributes and our database consists of almost 8500 observations from the second half of 1995 to the end of 1998. Our econometric test indicates that standard housing and municipality attributes are important determinants to sales prices. We have also employed spatial econometric techniqes and have found that spatial specified regressions improved the explanatory power for the models. The estimated constant quality appreciation rates for all MDCBs differ significantly from those reported by Statistics Sweden. When the constant quality price trend is estimated on a yearly basis there are hardly any differences among the estimated parameters whether all MDCBs are in the sample or if the sample is split up into submarkets. However, estimating quarterly constant quality price trends gives another picture.

JEL: R210, R310, G120

Keywords: House price, hedonic modelling, constant quality price index and spatial econometrics

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* I would like to thank Gunnar Rosenqvist of the University of Helsinki, for exhaustive comments on an earlier version of this paper. Olle Färnquist (National Land Survey of Sweden, Gävle) and Bengt Turner (Institute for Housing and Urban Research, Uppsala University) have contributed with valuable comments during different stages in the process while I was writing this paper and Daniel Ogden for preservation of terminology and usage in my English. The Swedish Council for Building Research has provided support for this research.

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Introduction

A rather large part of a developed nation's non-human capital consists of real estate. Sweden is no exception to this rule and according to the latest survey of national wealth, 66 per cent of fixed tangible capital was made up by real estate (building and construction).[1] According to the survey the total value of real estate in 1995 was 3.2 trillions SEK - twice the size of the Swedish GDP. Households and non-financial corporate sector possessions amounted to 1 and 1.2 trillions respectively. Local and central government are holding most of the remanding 1 trillion.

The occurrence of booms and busts in the real estate markets is also well-known and we have witnessed huge changes in property values from time to time during the last past decades. This massive amount of wealth in real estate means of course that price changes will result in big changes in wealth; if prices for real estate change by 5 per cent, wealth will change with some 160 billion SEK, which is approximately 20 per cent of the wage sum for Swedish households. The capital gains and losses caused by price changes in real estate will have an impact on the national economy.[2]

Having accurate measures the price trends is crucial to understanding the behaviour of the real estate market. A substantial literature exists on the measurements of prices for non-standard assets such as real estate.[3] There are two major problems to be overcome in constructing this price index as the relative infrequency of sales of buildings and the heterogeneity in characteristics across building units. Simple price indexes based on mean prices of units sold for a certain period do not take into account the characteristics of the building sold. These simple price indexes are thus unable to distinguish between movements in prices and changes in the composition of units sold from one period to the next.

The indexes compiled by Catella Property Management and Celexa Aberdeen Asset Management in Stockholm, for instance, are examples of this type of simple price index for commercial real estate.[4] The price index for commercial real estate compiled by Statistics Sweden based on an average of the ratio for sales prices to assessed value have certain features of a constant quality index since the assessed value reflects the market value of the house at a specific point in time. Still the weights in the Statistics Sweden's index are not

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[1] See Statistiska Meddelanden N 10 SM 9501, Appendix 3, page 55, Statistic Sweden

[2] Several empirical studies have shown that house prices and the value of household ownership of property affect consumption and saving. For an international survey see for instance *World Economic Outlook*, Chapter III (IMF 2000). For Swedish studies see e.g. Berg and Bergström (1995), Agell, Berg and Edin (1995), Englund, Hendershott and Turner (1995), Ekman (1997) and Hort (1998). For an overview of the Nordic countries, see Berg (1994).

[3] For surveys of techniques used in estimating house prices see for instance *Journal of Housing Research*, **6**, nr. 3 and *The Journal of Real Estate Finance and Economics*, 14, nr 1-2, Jan/March 1997.

[4] It can be noted that the Swedish Riksbank uses Celexa Aberdeen's price indexes for commercial real estate in their appraisal of tendencies in the financial system and their implications for stability, see *Financial Stability Report 2001*, Sveriges Riksbank, May 2001

constant over the time. Years with more or less sales in the urban or rural areas will change weights in the index and probably create a bias in the price trend since the price level and appreciation rates differ substantially between different areas of Sweden. Even this index thus has some of the shortcomings that are associated with price indexes based on the mean housing prices for a given period.

The accurate measurement of housing and real estate price trends is thus crucial to understanding market behaviour. For example, investigations about the ‘‘efficiency’’ of the housing market depend crucially upon specific techniques which generate the price indexes used to measure the returns to arbitrage. Models which investigate the determinants of speculative bubbles in real estate also rely on the techniques for the measurement of prices. Real estate markets have also become more integrated with financial markets and the computation of housing prices has become of great practical importance to investors who chose among portfolios composed of real estate securities and other assets.

Constructing a price index for financial assets that trade frequently and regularly is normally a straightforward exercise. In contrast, infrequent trading and the heterogeneity of real estate require an entirely different methodology. The dominant approaches used for constructing price indexes are hedonic models, the repeat sales method and the hybrid models that combine the two models mentioned above. Hedonic models take into account the heterogeneity of the estate by incorporating the physical and locational characteristic of the units traded. Using the hedonic and the hybrid approaches makes it possible to extract the price trend for constant-quality house. The repeat sales method only considers properties that have been sold at least twice. Heterogeneity problems will be minimized since at least two transaction prices on the same property are observed.

Quite a few studies have analysed the determinants of prices on owner occupied houses in Sweden using the hedonic and the hybrid approach.[5] Concerning other parts of the real estate sector only one introductory study has been made for multi-dwelling buildings and commercial buildings.[6] In this paper we will concentrate on studying the price determinants for multi-dwelling and commercial buildings (MDCBs) using high quality data and state of the art techniques in the econometric work. Our econometric test, using spatial econometric methods, indicates that standard housing and municipality attributes are important determinants fore sales prices. A high degree of significant regional differences is also detected. In the empirical analysis we also conclude that interest subsidies to MDCBs are (almost) fully capitalised and that rent control lowers the price per m^2 in some submarkets. The estimated constant quality appreciation rates for all MDCBs differ significantly

[5] For studies using the hedonic technique see Berger (1998a, 1998b) and Wigren (1986). Englund, Quigley and Redfearn (1998, 1999) used the hybrid approach in their study.
[6] See Turner (2001).

from those reported by Statistics Sweden. When the constant quality price trend is estimated on a yearly basis there are hardly any differences among the estimated parameters whether all MDCBs are in the sample or if the sample is split up in sub markets. However, estimating quarterly constant quality price trends gives another picture. A significant price trend for MDCBs with more than 75 per cent dwellings can be identified from the third quarter of 1996. The price trend for MDCBs with 25-75 per cent and less than 25 per cent dwellings take off a quarter later and lasts until the middle of 1998. The difference in the price trend among the three categories of buildings is of course an indication that the three submarkets react differently to the economic upswings and downturns that took place during the end of the 1990s.

The MDCB market in Sweden – stylised facts

More than 120 000 units of multi-dwelling buildings and commercial buildings exist in Sweden. More than 100 000 of these units have been used for dwellings into a varying degree. From table 1 can we learn that more than 75 per cent of the premises are used for dwellings in nearly 60 per cent of the total number of buildings. The two remaining groups of MDCBs with 75 to 25 per cent and less than 25 per cent dwellings are evenly distributed. The difference between the total number of buildings and those used for dwellings is approximately 17 000. These 17 000 estates are sites, office premises, parking buildings, hotels and restaurants. In our empirical work we will concentrate on the group of MDCBs with dwellings and exclude the last mentioned group of estates.

Table 1 Number of units and assessed value for multi-dwelling buildings and commercial buildings, MDCB, 2000

	Number of units	Assessed value (basvärde) billion SEK
MDCB, total	123084	945
The share of the premises used for dwellings in MDCBs		
More than 75 % (320)	61391	456
Between 75% and 25 % (321)	23441	207
Less than 25 % (325)	21363	222
Sub total	106195	885

Source: Statistiska Meddelanden, Bo 37 SM 0001, page 7. Statistics Sweden

The MDCBs assessed value for the year 2000 amounts to approximately 900 billions. This figure is also an estimate of the market value of these estates two years earlier. The assessed value of a real estate holding is the tax base for taxing these properties. According to the tax law the assessed value of the property should correspond to 75 per cent of its market value (on average) two years before the taxation year. Correspondingly, the estimated market value of MDCBs for 1998 amounts to some 70 per cent of GDP.

The most sophisticated price index for commercial real estate in Sweden for the time being is the ratio of transaction prices to assessed value compiled by Statistics Sweden. As already mentioned the tax value of the property is required to correspond to 75% of its market value (on average) two years before the taxation year. Every six years all property in a certain category of real estate is subject to assessment. Between the years of taxation the model for calculating the assessed value is updated to reflect price changes in local property markets. In short, the model used to determine assessed value mainly uses rents, location and vintage of the property as determinants.[7]

To obtain a price index the reported sales prices have been standardised by the assessed value for each property.[8] Statistics Sweden has supplied us with a time series for (current) prices of total MDCBs since 1981.[9] The price index in current prices and real price together with the average sales per year are displayed in figure 1. The trend of the real price index has been worked out by dividing the nominal index by the consumer price index. The difference between the two prices (nominal and real) is thus linked to the general price trend in the economy. It is also possible to follow the number of sales in the same graph.[10] The average value of the number of sales for the sample period was more than 2700 a year and the number of transactions fluctuates, which obviously is caused by the business cycle. The average for the yearly turnover between 1995-99 for MDCBs was SEK 25 billion, which gives a turnover rate of around 3 per cent.

Between 1981-2000 the nominal price index for MDCBs increased by more than 13 per cent (yearly average). From a peek in 1990 the prices fell back and stayed put during 1993-96. The slump during the beginning of the 1990s ended up in a more then 25 per cent decrease (peak to trough). From 1996 and onwards the price trend picked up again.

Up to the beginning of the 1990s the inflation rate has been rather high in Sweden. As a consequence of the high rate of inflation during the 1980s the appreciation of real prices is far below the nominal price trend; the average real appreciation rate from 1981-2000 amounts to 6 per cent a year. The bust of the 1990s caused a fall in real prices of an astounding 40 per cent! (1990-95). During the second half of the 1990s real prices started to

[7] The Ministry of Finance, the National Tax Board and the National Land Survey of Sweden implement property taxation in Sweden. The National Tax Board is the body that has the main responsibility for the administration of property taxes. The National Land Survey of Sweden builds and updates the valuation models that determine the assessment values. For this purpose they use data from the cadastral survey and surveys of the General and Special Assessment of Real Estate.

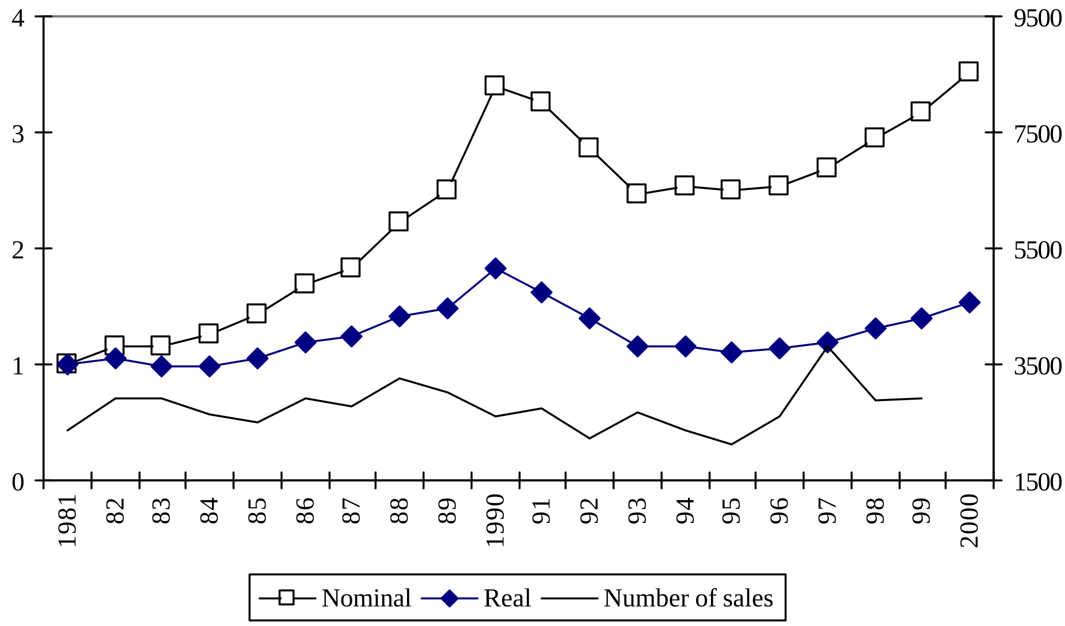
[8] The index was constructed as $\Sigma P_{it}/\Sigma V_{it}$ where P_{it} and V_{it} corresponds to the price and assessed value of the ith house sold in time period t.

[9] Since 1981 the assessment value for MDCBs has been recalculated twice. The recalculation normally causes shifts in the price trend but Statistic Sweden has compiled a comparable time series.

[10] Remember that numbers of sales are the weights in Statistics Sweden's price index and the numbers of sales of different types of buildings are not constant over the year. The index is thus not a perfect proper constant quality housing price index.

pick up but the real price level was still 18 per cent below the peak level for the last observation in the sample.

Figure 1 Trends in the nominal and real price level (logarithms and left-hand scale) and number of sales of multi-dwelling and commercial buildings, MDCB, (320, 321 and 325) (right-hand scale), yearly data 1981 to 2000



Source: Martin Verhage, Statistics Sweden.

Remember that we are discussing aggregate numbers. Studying more densely populated areas in Sweden gives another picture. For instance Englund (1999) reports that the price increase for prime location commercial (non-residential) properties in Stockholm during the 1980s was much higher in the Stockholm area than elsewhere in Europe. According to the index used by Englund, prices slumped in nominal terms by over 50 per cent between 1990-93 in Stockholm.[11] The boom to bust in real estate prices was most severe in the Stockholm area but all big cities had significant price changes during these years – see e.g. Jaffe (1994).

The hedonic method and spatial econometrics

As already has been stressed the dominant approaches used for constructing price indexes are hedonic models, the repeat sales method and the hybrid models that combines the two above mentioned models. In this paper the hedonic method will be used. In our data set approximately 350 units have been sold twice but we consider that the sample is too small for using the hybrid approach.

[11] Catella Property Management, Stockholm, compiles the index. The Catella index is a simple price index based on the mean prices and does not consider the characteristics or qualities of the buildings.

Hedonic models require extensive data sets which should include transactions prices, the entire set of characteristics of each property and even a set of neighbourhood characteristics. To obtain all that data is of course not possible, so normally variables are missing when the models are specified and estimated. Recently the method of controlling for spatial autocorrelation has gained growing popularity in applied statistical work since this method in a way copes with the problem of missing variables. One reason that house prices might be spatially autocorrelated is that property values in the same neighbourhood capitalise shared location amenities for which data normally is not available. If spatial autocorrelation is present in a model the resulting parameter estimates and confidence intervals for these parameters will be inefficient.

Even if all data necessary is available there are still problems with sample selection and the functional form of the hedonic model. Linear, multiplicative, semi-log, square root or Box-Cox transformed functional forms have been considered in the literature. Experiments with the functional forms have been performed and the results of the tests favours the multiplicative or log-linear model that is used throughout in this the paper.[12]

A hedonic price equation is simply a relationship between housing unit attributes and the market price of the property. Estimating a hedonic equation gives an estimate of the implicit price or valuation of each attribute. We specify the relation between market price and attributes in equation (1) as a multiplicative model.

$$P = a\left(\prod_{i=1}^{m} X_i^{b_i}\right) e^{\left(\sum_{j=m+1}^{n} b_j X_j + \sum_{t=1}^{T} d_t D_t\right)} \qquad (1)$$

P the price of the building,
X_i the ith continuously measured attributes (i = 1,…, m),
X_j the jth attributes measured as ratio or binary ($j = m + 1,\ldots, n$),
D_t a dummy variable equal to 1 if the property sold during period t and equal to 0 otherwise.

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[12] The modified *J* test which Green (1997) has labelled as the P_E *test* has been used. This test can be used to test different functional specifications against each other. The log-linear model has been tested against linear, semi-log and square root specification and the results of these rejected the two latest specifications. The linear model could not be rejected with the P_E *test*. An additional test was run with Box-Cox transformation. The test was set up with two alternative models which both are modified forms of equation (2):
$(P^l-1)/l = b_0 + \sum_{i=1}^{m} b_i (X_i^l - 1)/l + \ldots$.and $\ln P = b_0 + \sum_{i=1}^{m} b_i (X_i^l - 1)/l + ..$, where ? is a free parameter. The models have then been estimated conditionally on ?. The highest log-likelihood and R^2 was found for values close to zero for ? for both models. It can be shown that if ?=0 than $(P^l - 1)/l \approx \ln P$ and $(X^l - 1)/l \approx \ln X$. Thus, the test favours the log-linear specification. The results of the tests are available from the author upon request. The software used is EVIEWS 4.0.

In specifying equation (1) it is implicitly assumed that $ß_1$, …., $ß_m$ are constant over time i.e. the relative market valuation does not change for the X_i attributes. Changes in attributes X_j will cause shifts in the price of the building; $ß_{m+1}X_{m+1}$, …., $ß_n X_n$ will add to the intercept in the model. The same goes for the time-defined dummy variable. In the model the yearly appreciation rates for a constant quality house can be derived directly from the estimated parameters d_t.[13] Rewriting equation (1) as a log-linear model and adding a property specific random residual error term we get:

$$\ln P = b_0 + \sum_{i=1}^{m} b_i \ln X_i + \sum_{j=m+1}^{n} b_j X_j + \sum_{t=1}^{T} d_t D_t + e \qquad (2)$$

From equation (2) the constant quality price index, d_t, can be derived. If one can assume that the ß–parameters are constant over time the constant quality index can be used as an estimate on the rate of appreciation without any loss of information.

Spatial autocorrelation

It has already been pointed out in the literature that if spatial autocorrelation is present in a model the resulting parameter estimates and confidence intervals for these parameters will be inefficient. Using ordinary least squares to estimate transaction prices of real estate from multiple neighbouring locations may produce biased and inconsistent parameters estimates. As we already pointed out one reason for this phenomenon might be that houses in the same neighbourhood capitalise shared location amenities for which data normally is not available. One solution to this problem is to set up a spatial autoregressive model and we here follow LeSage(2001) who shows that a general spatial autoregressive model can be written as:

$$y = rW_1 y + Xb + u, \qquad u = lW_2 u + e \quad \text{and} \quad e \approx N(0, s^2 I_n) \qquad (3)$$

y is a vector with *nx1* cross-sectional dependent variables and *X* represents a *nxk* matrix of dependent variables.[14] W_1 and W_2 are known *nxn* spatial weight matrices that tell how much influence neighbouring observation has on the observation in question. *?* and *?* are unknown autoregressive and autocorrelation parameters respectively.

In our econometric work we will concentrate on two models: the spatial error model (SEM) and the spatial autoregressive model (SAR). The first-mentioned model falls out from equation (3) if we assume that $W_1 = 0$, i.e.

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[13] Quarterly or monthly dummy variables can of course be used if the data allow for such high frequencies.

[14] It is easy to translate the symbols of equation (3) over to those used in equation (2). *y* is a vector of the logarithm of price per m^2 and *Xß* is a matrix containing the parameters and variables but not the error term of the right-hand side of equation (2).

$$y = X b + u, \quad u = l W_2 u + e \quad \text{and} \quad e \approx N(0, s^2 I_n)$$

The SAR is derived from equation (3) if we assume that $W_2 = 0$, i.e.

$$y = r W_1 y + X b + u, \quad e \approx N(0, s^2 I_n)$$

The mixed regressive-spatial autoregressive model is analogous to the lagged dependent variable model used for time series.

For the SEM specification the weight matrix is defined as a first order contiguities matrix. For the SAR model, apart from the specification of W_1 as first order contiguities matrix, we have also used a matrix specified from different numbers of nearest neighbours. To construct the contiguity weight matrices the Delaunay routine is used that, in short, choose some of the nearest surrounding neighbours, which means that different observations can have different number of neighbours in the weight matrix. We experimented with one to three of the nearest neighbours in the alternative approach in constructing the weight matrix. The matrix with only one neighbour gave the best result in the econometric test.[15] In spatial econometrics the estimation is carried out conditional to the chosen spatial weight matrix and for that reason experiments with different econometric spatial specifications have been undertaken.

The econometric result on Swedish data for MDCBs presented in Andersson (2001) indicates that spatial autocorrelation matters. Andersson uses a subsample of our data set for the three big cities in Sweden: Stockholm, Gothenburg and Malmö. In all the three big cities the price models improve significantly and some parameter values change when controlling for spatial autocorrelation. In the econometric work in this paper we will test for the presence of spatial autocorrelation for the full national sample of MDCBs.

Before we start to discuss the data used in the econometric tests, is it worth mentioning that we have tested if interest-subsidised loans for MDCBs are fully reflected in the market prices. Interest-subsidised loans for apartment buildings and owner occupied houses are an import feature of Swedish housing policy since the 1970s. In the appendix a short account of the construction of these subsidies is given together with a discussion of how we model and empiricaly test the impact of subsidies. The conclusions drawn from these tests are that subsidies are (almost) fully capitalised. This means that we can concentrate on models specified either with subsidies or without. From now on we concentrate on the models where interest rate subsidies are not used explicitly.

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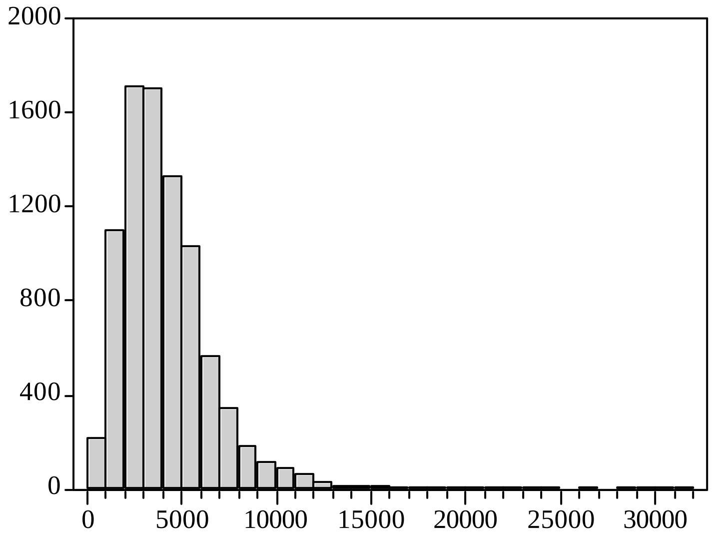
[15] The routines used XY2CONT and MAKE_NNW respectively come from LeSage's Spatial Econometric Toolbok for MATLAB version 5.2.

Data

The dataset from the National Land Survey of Sweden, NLSS, consists of housing attribute variables such as e.g. sales prices, rents, space, utilisation, vintage and geographical location of the building. The sample for MDCBs comprehend data from the second half of 1995 to the end of 1988 and the number of observations used is over 8500. As already stated we concentrate on MDCBs with dwellings. Sites, office premises, parking buildings, hotels and restaurants are excluded from the sample. The dependent variable in the models average price per m^2 is displayed in figure 2. From the figure it can be learned that the average price per m^2 was some SEK 4000 and that the distribution of the m^2 price is positively skewed with a median value of SEK 3700. The high value on the standard deviation for the variable also reveals that a long span exists between minimum and maximum values.

Figure 2 Sales price per square meters for MDCBs 1995-98



Series: Sales price per square meters (SEK),	
Observations 8575	
Mean	4194
Median	3709
Maximum	31804
Minimum	270
Std. Dev.	2554
Skewness	2.44
Kurtosis	17.05
Jarque-Bera	79126.36
Probability	0.00

We have also employed quite a few neighbourhood attributes or community variables in the empirical models and some basic statistics for these are displayed in table 2 together with the housing attributes variables from NLSS. The variables in the table are stratified in four groups of municipalities. In the empirical work with the hedonic model we started out with nine different categories of municipalities but found that different types of categories could be added together for different samples of MDCBs.[16] The NLLS supplies the first eight variables in the table, which are also housing attributes. The numerical data for these housing attributes variables are all from 1998.[17]

[16] We use the nine-fold classification made by the Swedish Association of Local Authorities for different types of municipalities. The regrouping used for descriptive purposes is the following: Big cities (Stockholm, Gothenburg and Malmö) [K1]; Big municipalities [K3]; Suburban, industrial, sparsely populated and small municipalities [K2+K5+K7+K9]; Average size urban, rural and other semi-big municipalities [K4+K6+K8].

[17] Data is collected from the survey for the year 2000 for the General and Special Assessment of Real Estate.

Table 2 Descriptive statistics for the variables in the hedonic models

	Big cities; Stockholm, Gothenburg and Malmö - K1					Big municipalities (Benchmark) - K3				
	Mean	Max	Mini	Std.D.	Obs	Mean	Max	Mini	Std.D.	Obs
1. Price per m^2	6761	31804	861	3566	1461	4392	16953	400	1894	2578
2. Price per m2, ex subsidies	6731	31804	861	3566	1461	4269	16953	5	1880	2568
3. Rent per m2	769	2750	70	193	1233	673	8750	0	274	2358
4. Ratio of rents from flats to the total income from rents	0.76	1.00	0.00	0.32	1461	0.79	1.00	0.00	0.35	2578
5. Owners' relative utilisation of the premises	0.17	1	0	0.35	1399	0.06	1	0	0.19	2454
6. Ratio of vacant space	0.02	1	0	0.08	1399	0.04	1	0	0.12	2454
7. Age of the building	41	69	1	20.8	1453	34	69	1	19.4	2578
8. Distance to centre, meters	3074	14970	113	2207	1461	3734	56272	15	6247	2578
9. Ratio of vacant flats in the area	0.01	0.07	0.00	0.01	1461	0.04	0.22	0.00	0.04	2524
10. Tobin's Q	1.20	1.38	1.00	0.15	1461	0.83	1.10	0.49	0.11	2578
11. Ratio higher to lower education	0.96	1.25	0.59	0.22	1461	0.68	1.94	0.39	0.28	2578
12. Average income*10^3	206	230	182	16	1461	217	246	188	11	2515
13. Ratio of total employees to those employees living in the area	1.36	1.43	1.27	0.07	1461	1.06	1.21	0.91	0.06	2515
14. Ratio of net migration¤	0.01	0.02	0.01	0.00	1461	0.00	0.02	-0.01	0.00	2578
15. Ratio of foreign subjects ¤	0.11	0.12	0.10	0.00	1461	0.05	0.11	0.02	0.02	2578
16. Ratio of age group 20-29¤	0.16	0.17	0.15	0.01	1461	0.15	0.21	0.11	0.02	2578
17. Ratio of age group 50-64¤	0.15	0.16	0.14	0.01	1461	0.17	0.19	0.14	0.01	2578
18. Total population *10^{-3}	527	722	240	198	1461	95	185	51	26	2578
19. Ratio of votes on non-Left parties	0.41	0.44	0.36	0.03	1461	0.39	0.48	0.28	0.05	2578
	Suburban, industrial, sparsely populated and small municipalities - K2+K5+K7+K9					Average size urban, rural and other semi-big municipalities - K4+K6+K8				
	Mean	Max	Mini	Std.D.	Obs	Mean	Max	Mini	Std.D.	Obs
1. Price per m^2	3386	16556	271	2053	1949	3157	12409	348	1539	2587
2. Price per m2, ex subsidies	3207	16556	18	2048	1906	2962	12409	12	1468	2544
3. Rent per m2	618	3898	0	197	1627	607	1407	0	137	2230
4. Ratio of rents from flats to the total income from rents	0.66	1.00	0.00	0.39	1951	0.73	1.00	0.00	0.37	2588
5. Owners' relative utilisation of the premises	0.12	1	0	0.28	1837	0.09	1	0	0.23	2414
6. Ratio of vacant space	0.06	1	0	0.16	1837	0.06	1	0	0.16	2414
7. Age of the building	33	69	1	20.0	1950	35	69	1	20.8	2587
8. Distance to centre, meters	5634	131819	20	11585	1908	4582	110018	26	8108	2562
9. Ratio of vacant flats in the area	0.07	0.57	0.00	0.06	1797	0.07	0.29	0.00	0.05	2527
10. Tobin's Q	0.72	2.30	0.32	0.32	1950	0.68	1.11	0.37	0.14	2580
11. Ratio higher to lower education	0.50	2.63	0.22	0.34	1950	0.43	0.72	0.23	0.09	2588
12. Average income*10^3	234	414	187	30	1883	221	269	180	13	2445
13. Ratio of total employees to those employees living in the area	0.93	2.08	0.31	0.29	1883	0.94	1.44	0.47	0.11	2445
14. Ratio of net migration¤	0.00	0.07	-0.03	0.01	1950	0.00	0.04	-0.02	0.01	2586
15. Ratio of foreign subjects ¤	0.05	0.26	0.01	0.03	1950	0.04	0.10	0.01	0.02	2586
16. Ratio of age group 20-29¤	0.12	0.17	0.08	0.02	1950	0.12	0.17	0.08	0.01	2586
17. Ratio of age group 50-64¤	0.17	0.23	0.14	0.01	1950	0.17	0.20	0.14	0.01	2586
18. Total population *10^{-3}	23	79	3	16	1950	29	58	0	12	2588
19. Ratio of votes on non-Left parties	0.43	0.83	0.12	0.12	1950	0.40	0.72	0.14	0.09	2588

¤ Divided by the total population.

The rest of the variables come from another source and we classify these variables as neighbourhood attributes.[18] Each neighbourhood is defined as a municipality and there are 289 municipalities. The neighbourhood variables are collected for different years and have their first observation from at least 1993. Some of the variables are collected for years even further back in time. The reason for using data collected so far back is that this will allow us to experiment with time lags in the hedonic model. In the empirical tests all variables for municipalities attributes are specified with a lag in the models; the log of the sales price per m^2 for 1995 will be regressed by the values of the municipalities attributes for 1994 and so forth.

Table 2 contains a lot of numbers but it is easy to read. The numbers are the expected ones - the price per m^2 for MDCBs was highest in the big cities etc. - and we see no point in commenting on the numbers for the different groups of municipalities for all variables. All the variables in table 2 are included in the statistical test of the hedonic models and in table 3 a short definition or description of the variables is given if it is not self-evident. We also make a brief comment on the variables expected impact in the statistical models in the table.

[18] Tommy Berger at IBF has supplied us with present value estimates for the interest rate subsidies. This has made it possible to compile the price per m^2 for MDCBs excluding subsidies and this data are used in the empirical test in the appendix. Mr Berger has also supplied us with estimates of Tobin's Q (market price to the replacement value of an asset) for family homes. We greatly appreciate all the help we have received from Mr Berger. - To calculate the distance of the building to the community centre it is necessary to have information about the geographical position of the centre. Lena Magnusson at IBF has compiled data for longitude and latitude for the centre of the 289 municipalities and the author is indebted to them for this. Most of the neighbourhood attributes variables have been collected from Sweden's Statistical Databases on the Internet. The database is run by Statistic Sweden – www.scb.se.

Table 3 Definition and comments on the models independent variables

		Type	Description and motivation.	Excepted effect
	Housing attributes			
2	Rent per m^2	C	Log specification. Positive elasticity is expected	+
3	Ratio of rents from flats to the total income from rents	R	Expect a negative effect due to rent control	-
4	Owners relative utilisation of the premises	R	A proxy for the degree of instant accessibility for the potential buyer. A positive effect on the dependent variable is expected.	+
5	Ratio of vacant space	R	Vacant space in the premises might imply less rental income and thus a negative effect	-
6	Age of the building	C	Log specification. Depreciation of the building - expect negative elasticity	-
7	Distance to centre, meters	C	Log specification. Buildings far away from the city centre are expected to be cheaper than those near the centre - expect a negative elasticity	-
	Municipality attributes			
8	Ratio of vacant flats in public housing sector	R	Proxy for measure of the demand for shelters – expect negative effect	-
9	Tobin's Q	R	Market price to the replacement value of owner occupied houses. A high Tobin's Q indicates in most cases high demand for housing which should be correlated with demand for flats – expect a positive effect	+
10	Ratio of higher to lower education	R	People with three or more years in at least upper secondary school to those with fever years. Higher education is correlated with income. High ratio will increase demand for housing – expect a positive effect	+
11	Average income	C	Log specification. Expect positive elasticity.	+
12	Ratio of total employees to those employees living in the area	R	"Commuting variable" - measures the working population during the daytime relative to the working population living in the municipalities. Expect a positive effect	+
13	Ratio of net migration[¤]	R	A positive net migration is correlated with higher economic activity - pull-effect. Expect a positive effect	+
14	Ratio of foreign subjects[¤]	R	Non-Swedish subjects	+-
15	Ratio of age group 20-29[¤]	R	A higher ratio of this cohort should increase demand for housing – positive demand effect	+
16	Ratio of age group 50-64[¤]	R	Higher ratio of this cohort decreases demand for housing – negative demand effect	-
17	Ratio of votes on non-Left parties	R	This ratio is highest in big and residential cities – captures presumably an income effect. Expect a positive sign.	+
	K1	B	Big cities: Stockholm, Gothenburg and Malmö	
	K2	B	Suburban municipalities	
	K3	B	Big municipalities (Used as a benchmark)	
	K4	B	Average size urban municipalities	
	K5	B	Industrial municipalities	
	K6	B	Rural municipalities	
	K7	B	Sparsely populated municipalities	
	K8	B	Other semi-big municipalities	
	K9	B	Small municipalities	

¤ The variable is divided by the total population in the municipalities. The numbers in the first column corresponds to the numbers of variables in the next table where the empirical results are displayed. The letters in the 3rd column identify variable type; C = continuously measured, R= ratio and B = binary (0,1)

Results

As already has been mentioned hedonic models for different categories of MDCBs specified as OLS models and spatial autocorrelation models will be tested. To restrict the number of tested models in the paper only the result from the OLS specification and for the spatial autoregressive models, SAR, where the Delaunay routine is used to construct the contiguity weight matrices are displayed. The results from the tested spatial autoregressive model, SEM, (with the same contiguity weight matrix specification as in the aboved mentioned SAR model) and the SAR model where the weight matrix specified from different numbers of nearest neighbour, are rather similar to the result presented from the chosen SAR model. [19]

Controlling for spatial correlations matters and gives a better fit. The difference between parameter estimates from OLS and the SAR model differs quit a lot for certain parameters and some of them might even be statistically significantly different from each other. The main propose of this paper is to estimate a constant quality price trend and the result for the three yearly dummy variables that capture this effect probably does not differ significantly between the two methods of estimation.

The results from the regression equations with the price per square meter for MDCBs as the dependent variable are reported in table 4. The sample ranges over 3½ year (second half of 1995 to the end of 1998) and contains almost 7000 observations. When estimating the models the full sample is used as well as different subsamples. The three subsamples are categorised from the relative number of dwellings in the building. The following samples are used:

a) full sample, All,
b) buildings with more than 75 per cent dwellings, 320,
c) buildings with less than 75 per cent but more than 25 per cent dwellings, 321, and
d) buildings with less than 25 per cent dwellings, 325.

Later on when the estimated equations are commentated on, we will use the code All, 320, 321 and 325 for identifying the different samples. The software used for the estimated models table 4 is MATLAB.

It is worth mentioning that an experiment with the logarithm of the selling prices as the dependent variable and the logarithm of total square meters of the premises as a right-hand variable instead of using the logarithm of the square meter price has been made. This specification increased adjusted R^2 considerably – to above 90 per cent – but the estimated parameter for the logarithm of total square meters turned out to be equal to unity. The elasticity between square meters and selling price is thus equal to one; buyers of MDCBs in general do not pay more per square meter for buildings with more square meters than

[19] The result from the tests discussed is available from the author upon request.

fewer, *ceteris paribus*. The alternative model specification did not affect the other estimated hedonic parameters compared with those results reported in table 4. Accordingly we can go on working with the logarithm of prices per m^2 as the dependent variable in our models without losing knowledge about determinants of prices.

White's residual test for heteroskedasticity for all four OLS equations in table 4 produced a significant result. This implies that usual OLS standard errors will be incorrect and for that reason White's heteroskedasticity consistent covariance matrix estimator has been used to obtain consistent values.[20] A necessary condition for getting a reliable estimated parameter for the constant quality index, d_t, is that all the other parameters in the model are stable. If the parameters of the model are not stable, a regression for every year has to be run and the constant quality price has to be calculated from a set of chosen values of the dependent variables. After sorted data according to dates when sales took place, recursive parameter estimate, recursive residuals, CUSUM and CUSUM of square test have been run.[21] An inspection of the recursive parameter estimate for the equations reveals that they seem to be rather stable over time. In none of the models could any significant change of any hedonic parameter be detected. The one-step-ahead forecast - recursive residuals –also produced acceptable results. Some residuals could be found outside the error band but not in a systematic way. The CUSUM test also turned out satisfactory - plots of the cumulative sum of residuals stayed inside the corridor of the 5% critical lines for all models. The CUSUM of square test, which maybe is the most rigorous test, showed that the cumulative squared residuals stayed in the corridor for more than half of the sample period when data for all MDCBs were used. When data for subsets of MDCBs were used the squared residuals left the corridor much earlier. This might be a result of some large forecast errors, which in turn may hinge on some outliers in the data.

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[20] This method provides more correct estimates of the coefficient covariances in the presence of heteroskedasticity of unknown form. If the heteroskedasticity in the residual is of known form the remedy is weighted least squares. If it is of unknown form White's heteroskedasticity consistent covariance matrix and the generalised method of moment, GMM can be used.

[21] EVIEW 4.0 has been used for the stability test since it is very powerful in this respect. To do the same stability test for the spatial regressions run with MATLAB will be computationally very burdensome and is beyond of the scope of this paper. The following tests have been run:
Recursive coefficient estimates. Estimating the models while increasing the sample window– starting with a few observations and ending up with the full sample. EVIEWS provide a plot of selected coefficients in the equation with a standard error band around the estimated coefficients. If the coefficient displays significant variation as more data is added to the estimating equation, it is a strong indication of instability.
Recursive residuals. The same techniques as with recursive coefficient estimates are used. At each step the last estimate of the model can be used to predict the next value of the dependent variable. The one-step-ahead forecast error resulting from this prediction is plotted together outside the standard error band. Residuals outside the standard error bands suggest instability in the parameters of the equation.
The CUSUM and CUSUM of square test. The first test is based on the cumulative sum of the recursive residuals. This option plots the cumulative sum of residuals together with the 5% critical lines. The second test is based on the squared cumulative sum of the recursive residuals and displays data in almost the same manner as the first test. The test finds parameter instability if the cumulative sum goes outside the area between the two critical lines.

We have also tested models for the full sample of MDCBs for two different sample periods: 1995-96 (2600 observations) and 1997-98 (4300 observations). Comparing the estimated parameters for these two periods reveals some changes in some parameters but nothing serious. The bold conclusion drawn from all these tests is that we can continue with the assumption that the estimated hedonic parameters are reasonably stable.

Appreciation rate and regions

The first reflection is that the explanatory power of the estimated models is quite high; the lowest number for adjusted R^2 is 60 per cent and the highest is more than 70 per cent. We can also learn that spatial autocorrelation matters since the fit is higher for the SAR models. The dummy variables for the three years 1996, 1997 and 1998 capture the constant quality price appreciation compared with 1995. Price appreciation was 5 per cent between 1995-96, 16 per cent between 1995-97 and 22 per cent between 1995-98 for the first two models estimated using the full sample (see also table 5). The estimated parameters for the price appreciations are almost the same for sector 320 and 321, irrespective of econometric specification. Our estimate for sector 325 indicates a higher appreciation for 1997 and 1998. The estimated numbers can also be seen as the real rate of constant quality price appreciation since the rate of inflation in Sweden was almost non-existent for these years.[22]

Our estimates of constant quality prices are higher compared with those compiled by Statistics Sweden as has been presented in figure 1. The price appreciations for Statistics Sweden's index of MDCBs were 2, 8 and 18 per cent between 1995-96, 1995-97 and 1995-98 respectively. The numbers are also displayed in table 5. A *t*-test indicates that our constant quality price estimates for 1997 and 1998 differ significantly from those compiled from Statistics Sweden's index. Thus, a constant quality index based on a model for prices for MDCBs gives significant higher estimates for the price trend than Statistics Sweden's index. As already has been discussed, Statistics Sweden's index is based on the ratio of reported sales prices to the assessed value of each property where the numbers of sales are the weights. It can also be learned from table 5 that the relative number of sales declined for subsample 320 and increased for the two other categories, although to a lesser extent for 321. The weights of each time period for the hedonic model are more complicated since the weights are a function of the number of sales and the variance in hedonic *X*–variables for both the specific time period and the full time period.[23]

[22] The rate of inflation for these years (based of the yearly average of consumer price index) amounted to 0.5, 0.5 and –0.1 per cent, respectively.
[23] See Hoesli, Giaccotto and Favarger (1997) for a pedagogical description of the simple multi-periodical hedonic model and the weights for different time periods for the constant quality price.

Table 4 Empirical results from estimations of the hedonic model with OLS and spatial econometric specifications. The dependent variable is the logarithm of price per square meters for MDCBs. Asymptotic t-values in brackets for the spatial models and White's heteroskedasticity consistent t-values for OLS

	320+321+325				320				321				325			
	OLS	I	SAR	II	OLS	III	SAR	IV	OLS	V	SAR	VI	OLS	VII	SAR	VIII
Constant	4.77	*9.42*	3.78	*13.30*	4.11	*6.75*	3.52	*7.96*	5.00	*4.39*	3.65	*3.65*	7.53	*5.23*	5.85	*49.65*
LN(Rent per m2)	0.55	*20.97*	0.51	*37.15*	0.74	*17.59*	0.68	*27.38*	0.70	*10.74*	0.66	*19.97*	0.41	*12.08*	0.40	*15.37*
Rents from flats to total rents	-0.13	*-9.26*	-0.09	*-8.55*	0.10	*1.80*	0.08	*1.53*	-0.20	*-5.09*	-0.17	*-5.02*	-0.17	*-2.30*	-0.15	*-1.85*
Owners relative util. of the prem	0.06	*2.06*	0.04	*1.54*	0.20	*6.48*	0.18	*6.72*	0.00	*0.03*	-0.02	*-0.48*	-0.29	*-3.29*	-0.25	*-2.62*
Ratio of vacant space	-0.69	*-14.73*	-0.63	*-17.38*	-0.70	*-10.95*	-0.65	*-15.06*	-0.56	*-6.16*	-0.53	*-6.71*	-0.73	*-6.08*	-0.71	*-6.35*
LN(Age of the building)	-0.19	*-32.69*	-0.19	*-38.60*	-0.18	*-28.05*	-0.18	*-32.68*	-0.18	*-12.48*	-0.19	*-14.60*	-0.13	*-6.72*	-0.14	*-7.53*
LN(Distance to centre)	-0.12	*-29.82*	-0.09	*-26.70*	-0.10	*-21.01*	-0.08	*-21.70*	-0.12	*-13.64*	-0.10	*-15.55*	-0.15	*-13.14*	-0.14	*-11.93*
Ratio of vacant flats in the area	-0.54	*-4.96*	-0.36	*-3.53*	-0.63	*-4.92*	-0.48	*-4.17*	-0.63	*-2.67*	-0.52	*-2.30*	-0.27	*-0.77*	-0.15	*-0.39*
Tobin’s Q	0.51	*12.28*	0.30	*7.48*	0.50	*10.07*	0.30	*6.38*	0.53	*6.36*	0.34	*4.26*	0.50	*3.22*	0.35	*2.50*
Ratio higher to lower education	0.10	*2.38*	0.10	*2.66*	0.00	*0.08*	0.04	*0.89*	0.13	*1.56*	0.08	*1.02*	0.38	*3.17*	0.27	*2.45*
LN(Average income)	0.86	*9.26*	0.54	*7.49*	0.91	*8.12*	0.57	*5.95*	0.83	*4.03*	0.68	*3.69*	0.31	*1.14*	0.17	*1.60*
"Commuting" variable	0.03	*1.03*	0.04	*1.30*	0.10	*2.41*	0.11	*3.08*	-0.09	*-1.50*	-0.05	*-0.82*	0.21	*1.89*	0.19	*1.78*
Ratio of net migration	3.57	*3.84*	2.22	*2.59*	3.01	*2.75*	2.00	*2.06*	3.06	*1.69*	1.86	*1.06*	6.89	*2.08*	5.32	*1.68*
Ratio of foreign subjects	-0.52	*-1.91*	-0.44	*-1.92*	-0.56	*-1.82*	-0.43	*-1.60*	-0.25	*-0.48*	-0.75	*-1.53*	-0.09	*-0.12*	-0.19	*-0.27*
Ratio of age group 20-29	2.47	*5.62*	1.19	*3.60*	2.74	*5.53*	1.45	*3.70*	2.43	*2.43*	1.58	*1.97*	0.83	*0.59*	0.46	*0.38*
Ratio of age group 50-64	-1.79	*-2.90*	-1.70	*-3.63*	-1.67	*-2.39*	-1.48	*-3.20*	-1.15	*-0.85*	-2.01	*-3.18*	-0.75	*-0.39*	-0.66	*-0.35*
Ratio of votes on non-Left parties	0.30	*4.61*	0.14	*2.57*	0.46	*6.33*	0.27	*4.38*	0.19	*1.29*	0.07	*0.60*	-0.17	*-0.82*	-0.14	*-0.66*
Dummy 1996	0.05	*3.07*	0.04	*2.98*	0.05	*3.02*	0.04	*2.91*	0.04	*1.11*	0.05	*1.50*	0.06	*0.90*	0.07	*1.00*
Dummy 1997	0.16	*9.67*	0.16	*10.14*	0.16	*8.56*	0.15	*8.94*	0.14	*3.72*	0.15	*4.36*	0.19	*2.92*	0.20	*3.07*
Dummy 1998	0.22	*12.01*	0.22	*13.36*	0.22	*10.71*	0.22	*12.27*	0.21	*5.39*	0.24	*6.45*	0.23	*3.22*	0.24	*3.48*
K1	0.13	*6.17*	0.08	*4.24*	0.06	*2.22*	0.02	*1.02*	0.19	*4.79*	0.13	*3.45*	0.23	*2.98*	0.11	*1.58*
K2+K5+K7+K9	-0.16	*-10.93*	-0.10	*-6.98*	-0.17	*-9.98*	-0.11	*-7.14*								
K4+K6+K8	-0.11	*-8.56*	-0.06	*-5.04*	-0.11	*-7.55*	-0.07	*-5.10*								
K4									-0.05	*-1.82*	-0.04	*-1.31*				
K2+K5+K8									-0.08	*-2.70*	-0.06	*-2.22*				
K7+K9									-0.14	*-3.09*	-0.11	*-3.11*				
K4+K5+K6													-0.10	*-2.89*	-0.08	*-2.12*
Rho			0.34	*26.69*			0.31	*19.82*			0.30	*10.18*			0.31	*7.17*
R^2 adj	0.6639		0.7006		0.6903		0.7198		0.7120		0.7385		0.6042		0.6371	
Variance of regession	0.1088		0.0966		0.0806		0.0725		0.1166		0.1042		0.183		0.1635	
No of observation	6811				4319				1498				857			

Table 5 Price appreciation and percentage of sales for the of MCDBs

	Price appreciation		Percentage of sales, subsample			
	Our estimates	Statistics Sweden	320	321	325	Number. of sales
1995	-	-	66	21	13	922
1996	5	2	63	24	13	2414
1997	16	8	60	23	17	2865
1998	22	18	56	25	19	2374

When controlling for the geographical location of the premises and for different econometric specifications, higher and lower levels of price per m^2 for different types of municipalities can be detected. One result is that there is a clear tendency that the SAR models display a substantially lower impact of regions for the full sample and for the sub-samples. We have also found that the estimated effect for different types of communities was not stable when the sample was split up in three categories. Examine for instance the dummy for Stockholm, Gothenburg and Malmö (big cities, K1). The parameter for the K1 variable is estimated conditional on big municipalities, K3. For the full sample the price level per m^2 is 13 and 8 percentage points higher respectively in big cities than for big municipalities. However, splitting up the sample into subsamples change this estimate considerably. For 320 (mainly dwellings) the price level is 6 and 2 percentage points higher respectively, for 321 (between 25 to 75 per cent dwellings) 19 and 13 percentage points higher respectively and for 325 (less than 25 per cent dwellings) 23 and 11 percentage points higher respectively compared to K3. We can also learn that other municipalities than those already mentioned had a lower price level than K3. For instance the price level for category 320 for municipalities K4, K6 and K8 was 11 and 7 percentage points lower respectively than for K3. All the reported results enhance our belief that constant quality price differs quit a lot between different regions in Sweden.

Housing attributes

The highest elasticity for the variable rent per m^2 is found for subsample 320 and 321. For model III - VI is this numbers are around 0.7 for the OLS specifications and slightly lower for the SAR specification. This means that a one per cent change in rent changes the price of the building by some 0.7 per cent. For subsample 325 the elasticity is even lover and ends up as 0.4. From a simple and classical model for computing present value this parameter is expected to be unity.[24] However we are not claiming that our theoretical basis is the simple present value model. The models we use have other variables included, which

[24] The classical Gordon's growth formula helps us with the intuition behind this statement. Assuming constant rents and constant risk adjusted return for the building from now to eternity then the price of the building (P) will be equal to the ratio between the rent (H) and risk adjusted return (R). After taking logs on Gordons formula the equation can be written as $\ln P=\ln H-\ln R$. The derivative on lnP with respect to lnH is thus equal to unity – the elasticity of the price with respect to rent is unity.

can be interpreted as proxy variables for expected future rents. From this point of view it is not so strange that our estimate of the elasticity for rents deviates from unity.

The estimated elasticises for rent per m^2 thus differ for different categories of buildings. Buildings in which more than 25 per cent of the premises are used for dwellings, 320 and 321, have a higher elasticity than the rest of MDCBs, 325, when the same econometric specification are compared. This difference in elasticises may be an effect of the Swedish system of rent control. The non-profit public housing corporations by and large set rents paid for dwellings. Due to special legislation the non-profit public housing sector has a leading role in determining the general level of rents in accordance with their zero-profit constraint thereby setting a cap on rents in privately owned dwellings.[25] The rents for that part of the premises that are not used for dwellings in MDCBs are market determined. One interpretation of the difference in the estimated elasticities is that the rent control is more binding for buildings with a higher ratio of rents from dwellings and present rents will be more important for the value of the building. For MDCBs with less than 25 per cent dwellings the effect of the rent control is less severe and other variables that are proxies for expected rents will be more important and consequently actual rents will be less important.

The system of rent control in Sweden might be important when the effect of the ratio of rents from flats to total rents should be interpreted. For buildings with more than 75 per cent dwellings, 320, the ratio of rents from dwellings to total rents is insignificant but significant with a negative sign for the two remaining categories and the size of the parameter differs a bit due to econometric specification. For the later categories this negative parameter can be interpreted as an alternative cost to use a certain area of the premises for dwellings. The estimates indicates that the price level will be –15 to – 5 per cent lover for buildings where 75 to 25 per cent of rents coming from dwellings. For subsample 325 the estimated interval range from –4 to 0.

Owners' relative utilisation of the building has no significant effect for subsample 321 but is significant with different signs for 320 and 325 and the parameter value differs a bit due to econometric specification. One explanation for this change in sign might be that the price of a building used mainly for dwellings is higher, the more space the owner controls or uses. The variable might be a proxy for the degree of instant accessibility for the potential buyer; if the buyer obtains more dwellings he can use them for purposes that give extra benefits. The negative sign for this variable for subsample 325 is trickier to explain. One possibility is that the variable in a way captures the same effect as the ratio of vacant space does; a "veiled" vacancy effect. When the owner of a premises with less than 25 per cent dwellings, can not rent out all the space in the building, then he has to use more space himself.

25 For details of the Swedish system of rent control see Turner (1988).

The three remaining variables of housing attributes have a straightforward interpretation. Vacant space in the premises, age of the building and distance to the (geographical) centre of the municipality have all the expected effect with some variation due to specification. The ratio of vacant space depresses the price per m^2 hardest for premises subsample 320 and 325, while the elasticity for the age of the building is lowest for 320 and 321. Buildings with less than 25 per cent dwellings are most sensitive to the distance from the municipali centre.

Municipality attributes

All the variables for municipally attributes are ratios except for the average income. The estimated coefficients also vary due to econometric specification. The elasticity for this continuous variable is significant but less than unity for buildings with more than 25 per cent and insignificant for buildings with less than 25 per cent dwellings.

All the variables expressed as ratios show the expected sign that already briefly have been indicated in table 3, but not all of the parameters are significant for each of the three categories we work with. The ratio of vacancies in the public housing sector depresses the price significantly for buildings with more the 25 per cent dwellings but is insignificant for those with less than 25 per cents dwellings. The estimated parameter for Tobin's Q is quite stable for all regression models. Oddly enough the education-ratio is only significant for the full sample and subsample 325. The "commuting variable" works for buildings with more than 75 per cent dwellings and almost for those buildings with less than 25 per cent dwellings while the ratio of net immigration in the municipality is significant for the same categories and the full sample.

We can also learn that the ratio of foreign subjects to the total population is not significant on the 5 per cent level for any sample. The two cohorts of different age groups show the expected and significant sign for most of the categories. Finally, the ratio of votes on non-Left parties inflates prices significantly for the full sample and subsample 320.

As been pointed out, the parameter estimates vary a bit between the different models' econometric specifications. The estimated parameters from the SAR contiguity model are in general lower than those computed by OLS, except from the estimates of the yearly rate of appreciation. The spatial specified regressions give a better fit than OLS and increase the coefficient of determination quite substantially in some cases. We have already argued that if spatial autocorrelation is present in a model the resulting parameter estimates and confidence intervals for this parameters will be inefficient. Our empirical result is an indication that it is worthwhile to use spatial econometrics when estimating hedonic price equations for MDCBs in Sweden and there is scope for exploring this method further since we have only used three simple standard spatial models. The literature in this field is expanding rapidly so there is a lot more that can be done.

Quarterly appreciation rates

We have already displayed (table 5) the yearly estimates for the constant quality parameters. As has been discussed, this parameter can be estimated for higher frequencies and we have run OLS regressions where quarterly dummy variables are used. The results from this experiment are shown in table 6 together with the yearly estimates from table 4. We have chosen to display only the constant quality parameters since the other parameters in regressions (I), (III), (V) and (VII) did not change. The adjusted R^2 improved very little indicating a marginally better fit with this specification of the hedonic models. No spatial regressions with quarterly appreciation rates have been run.

Table 6 Estimated quarterly (Q) and yearly (Y) constant quality appreciation rates

		320+321+325 (I)		320 (III)		321 (V)		325 (VII)	
		Q	Y	Q	Y	Q	Y	Q	Y
1996	1st	0.01 (0.71)		0.04 (1.86)		-0.03 -(0.56)		0.00 -(0.05)	
	2nd	0.02 (1.02)		0.05 (2.58)		-0.02 -(0.32)		-0.07 -(0.74)	
	3rd	0.06 (2.86)		0.07 (2.84)		0.05 (1.05)		0.06 (0.68)	
	4th	0.09 (4.30)	0.05 (3.07)	0.05 (2.40)	0.05 (3.02)	0.11 (2.39)	0.04 (1.11)	0.25 (2.97)	0.06 (0.90)
1997	1st	0.13 (6.21)		0.12 (5.27)		0.10 (2.18)		0.18 (2.03)	
	2nd	0.15 (7.50)		0.15 (6.98)		0.13 (2.89)		0.14 (1.70)	
	3rd	0.17 (7.50)		0.17 (6.82)		0.20 (3.40)		0.17 (2.06)	
	4th	0.19 (9.62)	0.16 (9.67)	0.20 (8.75)	0.16 (8.56)	0.16 (3.54)	0.14 (3.72)	0.23 (3.06)	0.19 (2.92)
1998	1st	0.20 (9.16)		0.21 (8.86)		0.21 (4.41)		0.10 (1.24)	
	2nd	0.24 (10.22)		0.21 (8.05)		0.22 (4.67)		0.32 (4.01)	
	3rd	0.20 (8.42)		0.22 (8.05)		0.18 (3.78)		0.13 (1.46)	
	4th	0.24 (10.12)	0.22 (12.01)	0.26 (9.75)	0.22 (10.71)	0.19 (3.51)	0.21 (5.39)	0.19 (2.07)	0.23 (3.22)

It is obvious from table 6 that more information is squeezed out of the data when quarterly dummy variables are used to estimate constant quality prices. Using the last two quarters of 1995 as a benchmark, constant quality prices for sector 320 show a positive significant price trend that starts in the 2nd quarter of 1996. The two remaining sectors pick up a positive price trend one quarter later but the trend drops between the 2nd and 3rd quarter of 1998. It is obvious that the Russian and Asian economic crisis in the second half of 1998 and its impact on the Swedish economy hit buildings with less than 75 per cent dwellings harder than those with over 75 per cent dwellings.

One lesson from the experiment with quarterly constant quality prices is that the price trend during the second half 1995 to the end of 1998 is quite different for the three defined submarkets. The submarket for buildings with mainly dwellings have had an almost steady increase in constant quality price since the second half of 1996 while prices started to take off a quarter later for the buildings with 25-75 per cent dwellings. The difference between the mentioned submarkets and the market for buildings with less than 25 dwellings is obvious. All this information is veiled in our estimates for constant quality prices on a yearly basis

Conclusion

In this paper the first more elaborated hedonic price model for MDCBs (multi-dwelling and commercial buildings) in Sweden is presented. The main propose of this work is to estimate a constant quality price trend and at the same time acquire knowledge about factors determining prices for MDCBs. We use high quality data for housing and municipality attributes and our database consists of almost 8500 observations from the second half of 1995 to the end of 1998. Data is also stratified into three submarkets depending on the proportion of rents from dwellings. Our econometric test indicates that the explanatory powers of the models are quite high and the parameters in the hedonic equations appear to be constant over time. Spatial econometric techniques has been used and we found that spatial specified regressions improved the explanatory power for the models.

Rent per m^2, the ratio of vacant space and the age of the building together with the distance to municipality's centre are important housing attributes determinants. The proportion of rents from dwellings to total rents has a negative effect, which is an indication of lower alternative cost for using the premises for dwellings – an effect of rent control. Among the municipality attributes it is worth mentioning the ratio of vacant flats, Tobin's Q, degree of commuting and age cohorts as being important variables. A high degree of significant regional differences is also detected. In the empirical analysis we also concluded that interest subsidies to buildings are (almost) fully capitalised.

When the constant quality price trend is estimated on a yearly basis there is hardly any differences among the estimated parameter whether all MDCBs are in the sample or if the sample is split up in subsamples after proportion of rents from dwellings. The reported constant quality price estimates for 1997 and 1998 are significantly higher than those that can be compiled from Statistics Sweden's index for MDCBs (Statistics Sweden's index is computed as the ratio of sales prices to assessed value of the building). However, estimating the quarterly constant quality price trends gives another picture. A statistical significant price trend can be identified for buildings with more than 75 per cent dwellings from the 3rd quarter of 1996. The price trend for buildings with 25-75 per cent and less than 25 per cent dwellings takes off a quarter later but the trend drops between the 2nd and 3rd quarter 1998. The difference in the price trend among the three categories is of course an indication that the three submarkets react differently to the economic upswings and downturns that took place during the end of the 1990s.

References

Agell J, L Berg and P-A Edin (1995), "The Swedish Boom to Bust Cycle - Tax reform, consumption and asset structure", *Swedish Economic Policy Review*, **2**, 319-56.

Andersson A (2001), "Spatial dependence in Swedish real estate prices", manuscript, August 2001, Department of Economics, Uppsala university.

Berg L (1994), "Household savings and debts: the experience of the Nordic countries", *Oxford Review of Economic Policy*, **10**, 42-53.

Berg L and R Bergström (1995), "Consumption, income, wealth and household debt - An econometric analysis of the Swedish experience 1970-1992", *Scandinavian Journal of Economics*, **97**, 421-39.

Berger T, P. Englund, P H Hendershott and B Turner (2000) "The Capitalization of Interest Subsidies: Evidence from Sweden" *Journal of Money, Credit, and Banking*, Volume 32, Number 2: 199-218, May

Berger, T (1998a), "Priser på egenskaper hos småhus", Institutet för bostadsforskning, Uppsala universitet, Arbetsrapport/Working Paper No. 14.

Berger, T (1998b), "Småhusens prisutveckling", Institutet för bostadsforskning, Uppsala universitet, Arbetsrapport/Working Paper No. 15.

Ekman E (1997), *Household and Corporate Behaviour under Uncertainty*, Economic Studies 29, Department of Economics, Uppsala University.

Englund P (1999). "The Swedish banking crisis: roots and consequences". *Oxford Review of Economic Policy*. 15. No 3. 80-97.

Englund P, J M Quigley and C L Redfearn (1998), "Improved Price Indexes for Real Estate: Measuring the Course of Swedish Housing Process", *Journal of Urban Economics*, **44**, No. 2, 171-196.

Englund P, J M Quigley and C L Redfearn (1999), "The Choice of Methodology for Computing Housing Price Indexes for Real Estate: Comparisons of Temporal Aggregation and Sample Definition", *Journal of Real Estate Finance and Economics*, **19**, No. 2, 91-112.

Englund P, P H Hendershott and B Turner (1995) "The tax reform and the housing market" *Swedish Economic Policy Review*, 2, Number 2, 321-356.

Englund P, P H Hendershott and B Turner (1995), "The tax reform and the housing market", *Swedish Economic Policy Review*, **2**, 319-56.

Financial Stability Report 2001, Sveriges Riksbank, May 2001.

Green W H (1997), *Econometric Analysis*, third edition, Prentice-Hall.

Hendershott P H and B. Turner (1999) "Estimating constant-quality capitalization rates and capitalization effects of below market financing". *Journal of Property Research*, Vol. 16. No. 2: 109-122.

Hort, K. (1998), "The Determinants of Urban House Price Fluctuations in Sweden 1968-1994", *Journal of Housing Economics*, **7**, No. 2, 93-120.

Jaffee, D M (1994), *Den svenska fastighetskrisen*, (The Swedish real estate crisis), Stockholm, SNS förlag.

Journal of Housing Research, **6**, no. 3
LeSage, J P (1999), “The theory and practice of spatial econometrics”, http://www.spatial-econometrics.com/.
The Journal of Real Estate Finance and Economics, **14**, no. 1-2, Jan/March 1997
Turner B (1988), “Economic and political aspects of negotiated rents in Sweden housing market”, *Journal of Real Estate Finance and Economics*, 1, 257-276.
Turner, B (2001), ”Hyreshusens överlåtelsepriser – en studie i prisbildningen” in Lindh, T (red), *Prisbildning och värdering av fastigheter*, Institutet för bostadsforskning, Uppsala universitet, Forskningsrapportt/Research Report 2000:4.
Hoesli M, C Giaccotto and P Favarger (1997), “Three new real estate price indices for Geneva, Switzerland”, *Journal of Real Estate Finance and Economics*, 15:1, 93-109.
Wigren R (1986), ”Småhuspriserna i Sverige”, SIB, Gävle, Foskningsrapport , SB:1
World Economic Outlook, May 2000, International Monetary Fund, Washington D.C.

Appendix

Prices and subsides

One important feature of Swedish housing policy since the 1970s is the interest-subsidised loans for apartment buildings and owner occupied houses. Long-term government guaranteed mortgage loans covering 95 to 99 per cent of approved building costs are granted to all new units and major renovations that comply with certain government regulations on maximum and minimum standards. These subsidised loans are fully assumable by subsequent buyers of the estate. Subsidised interest rates start at very low levels and increases year by year until they reach the market rate. According to present rules, vintages of apartment buildings built after 1980 are entitled to subsidised interest rates.

For instance, in 1989 loans to apartment buildings started at 2.7 per cent interest with 0.25 percentage point yearly increases until they reached the market interest rate. Present values for the subsidies of owner-occupied houses have been computed and analysed by Berger *et. al.* (2000). The same algorithm has been used to compile subsidies for MDCBs; calculation of the present value for the interest rate reduction for a standard housing loan since the effects of taxes is considered. The present value of the subsidies is compiled assuming static expectations for every period of time, that is, future tax rates and market interest rates as well as the rules for the subsidy will remain unchanged.[26]

Subsidised loans should affect the transaction price of MDCBs in a market economy. The value of buildings with subsidies (P) should exceed the value of the property without these subsidies (P´). In a perfect market the difference between these two prices should be equal to the present value of the subsidy (S). Defining γ as the parameter indicating what fraction of the value of the subsidy is capitalised into the price. The relation between prices and the present value of the subsidy can be written as:

[26] For details see Berger *et. al.* (2000).

$$P = P' + S \rightarrow P'(1+\frac{S}{P'})^{g} \qquad (4)$$

Taking natural logs on the above equation gives:

$$\ln P = \ln P' + g\ln(1+\frac{S}{P'}) \qquad (5)$$

If the present value of the subsidy is fully reflected in the price of the property we expect γ to be a positive unity coefficient. To incorporate the effects of subsidies in the hedonic price model, equation (2) can be rewritten as following:

$$\ln P' = b_0 + \sum_{i=1}^{m} b_i \ln X_i + \sum_{j=m+1}^{n} b_j X_j + \sum_{h=1}^{y} d_{t+h} D_{t+h} - g\ln(1+\frac{S}{P'}) + e \qquad (6)$$

Models (II) and (IV) have the highest fit and in these interest subsidies are included, see table A1. Regressions where these subsidies are included have a dependent price variable excluding the subsidies and for that reason the standard deviation of the dependent variable differs for the pair of models for the full sample and the subsample (the final line in table A1).[27] The estimated parameter for the subsidy variable for the different models range from –0.95 to –0.86. From our previous discussions we expect this parameter to be unity with a negative sign. A Wald test indicates that the parameter differs significantly, on five per cent level, from –1 for model (II) and model (IV) while the parameter differ insignificantly for model (VI) and (VIII).[28] Thus, for the full sample and subsample 320 are the interest rate subsidies are not fully capitalised from a statistical point of view. But the estimates are very close to –1 so it is no exaggeration to say that subsidies are almost fully capitalised.[29] If the models pair-by-pair for the full sample and the three subsamples are compared, the estimated parameter for all the other variables are very stable and identical except in one or two cases. If there is a difference between the parameters they are probably not significant.

An alternative iterative approach for estimating the effect of interest-subsidies has also been used. The test was set up with a modified version of equation (6).

$$\ln P' + g\ln(1+\frac{S}{P'}) = b_0 + \sum_{i=1}^{m} b_i \ln X_i + \sum_{j=m+1}^{n} b_j X_j + \sum_{h=1}^{y} d_{t+h} D_{t+h} + e \qquad (7)$$

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[27] On average 9 per cent of the buildings have interest subsidies. For the three subsamples these figure was 12.5, 5.2 and 1.1 per cent, respectively.
[28] The prob-value for the Wald test is 0.00, 0.01, 0.07 and 0.28, respectively.
[29] Our results are consistent with those reported by Turner and Hendershott (1999). Berger *et al* (2000) report unity capitalisation coefficient for owner-occupied houses in Sweden.

Equation (7) was estimated conditionally on the ?-parameter. The highest log-likelihood and R^2 was found for ?-parameters with numbers that were almost identical to those reported in table A1.

The conclusion of this analysis is that subsidies (almost) are fully capitalised and the parameters in the model stay put regardless of the way the models are specified. This also means that we can concentrate on models specified either with subsidies or without. In the main text we have used models where interest rate subsidies not are explicity used.

Table A1 Emperical result from estimation of the hedonic model. Dependent variable is the logarithm of square meter price. White heteroskedasticity consistent t-values in brackets

		320+321+325		320		321		325	
		I	II	III	IV	V	VI	VII	VIII
1	Constant	4.84	4.76	4.24	4.11	5.08	5.17	7.39	7.35
		(9.73)	(9.46)	(7.13)	(6.79)	(4.53)	(4.61)	(5.13)	(5.08)
2	LN(Rent per m2)	0.56	0.55	0.74	0.73	0.71	0.71	0.40	0.40
		(20.48)	(20.22)	(17.90)	(16.84)	(10.78)	(10.79)	(11.91)	(11.90)
3	Rents from flats to total rents	-0.14	-0.14	0.09	0.09	-0.20	-0.20	-0.16	-0.16
		-(9.68)	-(9.74)	(1.63)	(1.67)	-(4.99)	-(5.04)	-(2.11)	-(2.13)
4	Owners' relative utilisation of the premises	0.07	0.07	0.20	0.20	0.01	0.01	-0.29	-0.29
		(2.45)	(2.42)	(6.56)	(6.51)	(0.10)	(0.10)	-(3.25)	-(3.24)
5	Ratio of vacant space	-0.69	-0.70	-0.70	-0.72	-0.55	-0.55	-0.72	-0.72
		-(14.70)	-(14.52)	-(11.15)	-(10.90)	-(6.11)	-(6.15)	-(6.07)	-(6.05)
6	LN(Age of the building)	-0.19	-0.19	-0.18	-0.18	-0.18	-0.18	-0.13	-0.13
		-(33.18)	-(29.55)	-(28.62)	-(25.42)	-(12.42)	-(11.82)	-(6.67)	-(6.56)
7	LN(Distance to centre)	-0.12	-0.12	-0.10	-0.10	-0.12	-0.12	-0.15	-0.15
		-(29.82)	-(29.51)	-(21.31)	-(20.75)	-(13.78)	-(13.82)	-(12.99)	-(12.95)
8	Ratio of vacant flats in the area	-0.57	-0.58	-0.62	-0.63	-0.69	-0.69	-0.31	-0.30
		-(5.35)	-(5.35)	-(4.96)	-(4.98)	-(2.90)	-(2.90)	-(0.86)	-(0.85)
9	Tobin's Q	0.51	0.52	0.48	0.49	0.52	0.52	0.50	0.50
		(12.45)	(12.38)	(10.12)	(9.92)	(6.45)	(6.41)	(3.22)	(3.23)
10	Ratio higher to lower education	0.10	0.09	0.02	0.01	0.15	0.15	0.39	0.39
		(2.54)	(2.30)	(0.47)	(0.14)	(1.71)	(1.78)	(3.20)	(3.18)
11	LN(Average income)	0.83	0.84	0.88	0.89	0.81	0.79	0.33	0.34
		(9.15)	(9.15)	(8.07)	(8.05)	(3.99)	(3.89)	(1.22)	(1.23)
12	Ratio of total employees to those employees living in the	0.04	0.04	0.10	0.10	-0.08	-0.08	0.24	0.24
		(1.36)	(1.32)	(2.42)	(2.41)	-(1.37)	-(1.36)	(2.16)	(2.15)
13	Ratio of net migration	3.29	3.29	2.79	2.76	2.54	2.51	6.22	6.16
		(3.70)	(3.66)	(2.69)	(2.63)	(1.41)	(1.40)	(1.98)	(1.96)
14	Ratio of foreign subjects	-0.56	-0.59	-0.56	-0.61	-0.32	-0.29	-0.07	-0.10
		-(2.09)	-(2.19)	-(1.84)	-(2.00)	-(0.61)	-(0.56)	-(0.09)	-(0.13)
15	Ratio of age group 20-29	2.60	2.71	2.81	3.00	2.37	2.30	0.74	0.78
		(6.03)	(6.25)	(5.82)	(6.15)	(2.40)	(2.33)	(0.52)	(0.55)
16	Ratio of age group 50-64	-1.50	-1.44	-1.48	-1.45	-0.96	-0.88	-0.64	-0.63
		-(2.49)	-(2.38)	-(2.18)	-(2.11)	-(0.73)	-(0.67)	-(0.34)	-(0.33)
17	Ratio of votes on non-Left parties	0.31	0.32	0.47	0.50	0.20	0.22	-0.20	-0.20
		(4.83)	(4.97)	(6.53)	(6.80)	(1.37)	(1.48)	-(0.96)	-(0.96)
18	Dummy 1996	0.05	0.05	0.05	0.05	0.04	0.04	0.05	0.05
		(3.11)	(2.95)	(3.21)	(3.03)	(1.26)	(1.13)	(0.71)	(0.70)
19	Dummy 1997	0.16	0.16	0.16	0.16	0.15	0.14	0.18	0.18
		(9.84)	(9.76)	(8.95)	(8.89)	(3.85)	(3.73)	(2.66)	(2.63)
20	Dummy 1998	0.22	0.22	0.22	0.23	0.22	0.22	0.21	0.21
		(12.26)	(12.22)	(11.14)	(11.18)	(5.57)	(5.47)	(2.96)	(2.94)
21	K1	0.13	0.13	0.06	0.07	0.19	0.19	0.23	0.23
		(6.37)	(6.51)	(2.49)	(2.72)	(4.71)	(4.73)	(2.98)	(2.99)
22	K2+K5+K7+K9	-0.16	-0.16	-0.17	-0.17				
		-(10.98)	-(10.88)	-(10.04)	-(9.78)				
23	K4+K6+K8	-0.11	-0.11	-0.10	-0.10				
		-(8.84)	-(8.76)	-(7.52)	-(7.29)				
24	K4					-0.06	-0.06		
						-(2.08)	-(2.04)		
25	K2+K5+K8					-0.09	-0.09		
						-(2.93)	-(2.94)		
26	K7+K9					-0.14	-0.15		
						-(3.24)	-(3.32)		
27	K4+K5+K6							-0.12	-0.12
								-(3.18)	-(3.18)
28	LN(1+S/P')		-0.95		-0.97		-0.90		-0.86
			-(68.79)		-(75.06)		-(15.41)		-(6.46)
	R squared adj	0.6661	0.7402	0.6910	0.7958	0.7102	0.7191	0.6018	0.6015
	OBS	6940	6853	4511	4425	1551	1550	878	878
	SDDEP	0.562	0.636	0.508	0.622	0.633	0.643	0.676	0.676