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Prices on the Second-hand Market for Swedish Family Houses

– Correlation, Causation and Determinants*

by

Lennart Berg[✉]

Abstract. The structural differences and the dynamics in prices on the second-hand market for family houses in large (Stockholm, Gothenburg and Malmo), medium-sized, small and industrial cities and sparsely populated areas are analysed in this paper. The basic house price data set used in the analysis consists of constant quality monthly price indexes. The sample starts in January 1981 and ends in July 1997. The real price change in house prices for all seven regions display a high degree of autocorrelation, and the correlograms reveal a mean reverting pattern. The Granger causality test indicates that the real price changes for the Stockholm area “Granger cause” the price changes in the other areas. Thus, the real price change in the Stockholm area has a ripple effect on the six other areas. Both bivariate and multivariate Granger test indicate information content in a number of macroeconomic variables versus the real price changes for the Stockholm area. A simple VAR model was estimated with the price changes for family houses in the Stockholm area, a proxy for consumption growth and the change in the rate in the unemployment rate as endogenous variables and a number of exogenous macro variables. Experiments with impulse response functions show that a shock in the change in the rate of unemployment has a strong effect on real house prices and consumption.

Keywords: Regional house price, Granger causality, ripple effect, VAR modelling
JLE: E3, R0

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Introduction

During the 1980s and 1990s, the Swedish economy was characterised by strong fluctuations. Some of the things that distinguished the later part of the 1980s and the beginning of the 1990s were: a strong wage trend and growth in consumption, negative real interest rates after taxes for most households, a high real change in asset prices (shares, residential and commercial property, family houses, leisure property etc), high inflation, and record low unemployment. A few years into the 1990s the trends for these variables had changed completely. Some of the factors behind this boom-to-bust cycle were the economic overheating at the end of the 1980s, the Swedish tax reform, and the shock increase in real interest rates in the beginning of the 1990s.

Prices on the second-hand market for family houses declined in real terms for the entire country by about 25 per cent between 1981 and 1985. On the other hand, the subsequent period until the middle of 1991 was characterised by real price increases of nearly 40 per cent. Real prices fell then by 25 per cent from their highest level until the middle of 1996. The market has recovered since 1996, and up until the beginning of 1998 an increase in real prices of about 10 per cent has been noted. Only the Stockholm region on average has had a real increase in house prices of about 0.7 per cent (on a monthly basis), while all other regions that have been analysed in this essay have shown a negative trend.

The fluctuations in house prices that have been reported have resulted in strong capitalisation effects. If the real change in value of household ownership of houses is calculated, the value of these properties decreased by about SEK 40 000 per inhabitant between 1982 and 1986, and then increased by SEK 60 000 until 1991 to then fall by an entire SEK 85 000 until 1996. It is of course of great interest whether these changes in value affect the other parts of the economy. More than one-third of household wealth consists of the value of house properties, and an interesting question is whether capital gains and losses for these properties affect consumption and saving. One way of illustrating how household wealth, saving and consumption are linked is to start with the household balance sheet. A change in value in a household's wealth affects the household's debt ratio. If we assume that households wish to maintain a certain level of debt, an increase (decrease) in house prices means, *ceteris paribus*, that saving decreases (increases) when portfolio equilibrium is re-

established. Several empirical studies also show that house prices and the value of household ownership of property affect consumption and saving¹

When empirical analyses have been made of house prices on the second-hand market, Swedish as well as foreign studies have reported the existence of strong own price dynamics.² The existence of own price dynamics conflicts with one of the claims of the efficient market hypothesis. The efficient market hypothesis states *inter alia* that all available information has already been discounted or incorporated in the prices, and thus it should not be possible to use the price changes of previous earlier periods to predict today's price changes³

An alternative model that is often discussed is based on the asset market model of Poterba (1984). One of the claims of this model is that a shock on the market will give rise to the supply of houses being adapted, and since we are dealing with a supply of houses, this will be a drawn-out process. As a result of this, the change in house prices over time will first show a negative and then a positive correlation. The pattern of the change in house prices indicates that the price level will return to its original level. This type of process is usually called *mean reverting*. A strong existence of own price dynamics is consistent with mean reverting and thus with the Poterba model.

Regional trends for house prices are interesting for many reasons. English studies have found that price changes on the house market start in the London area and later spread to other regions. The phenomenon is called *the ripple effect*. If it is possible to ascertain that there is a stable connection regarding price trends for house prices between regions. This provides information that is useful for different decision-makers. We have already pointed to the problem of asset inflation and its wealth effects; increased house prices push up the value of household wealth, which can spill over into increased private consumption. If there is a leading region regarding house prices, it

¹ See Brodin and Nymoen (1992) for Norway, Koskela *et al* for Finland, Bayoumi (1993) for England and Berg and Bergström (1995) and Ekman (1997) for Sweden. For an overview of the Nordic countries, see Berg (1994).

² See Englund and Ioannides (1997) for an analysis of house prices in 15 OECD countries, Cho (1996) for an overview of American studies, Muellbauer and Murphy (1997) for an analysis of the British market and Hort (1997) and Berg and Lyhagen (1998) for analyses of the Swedish market.

³ See e.g. Campell *et al* (1997) for an overview of the efficient market hypothesis.

is possible at an early stage to get an idea of the anticipated price trends for the different regions.

Trends in house prices on the second-hand market is a central field for economists to study. Knowledge about what drives trends on this market is much sought for information by ministers of finance and central banks as well as real estate agents! We analyse two questions in this essay, namely:

- Firstly, we analyse price trends on the second-hand market for houses regionally as well as the aggregated level for the 1980s and 1990s. The question is whether any one or several regions lead price trends, i.e. if price impulses from any one region affect and dominate the others.
- Secondly, we analyse and discuss how different financial and real macro variables such as interest rates, the supply of money, and industrial production are related to trends in house prices. This analysis is made with an econometric model in order to study *inter alia* adaptation time in house prices from shocks or innovations in different variables. The analysis uses constant quality house price indexes for family houses in large (Stockholm, Gothenburg and Malmö), medium-sized, small, and industrial cities, and sparsely populated areas.⁴

The analysis also makes use of financial and real macro variables such as the industrial production, new car registration, unemployment, short and long-term real interest rates after taxes, the stock market and various liquidity measurements.

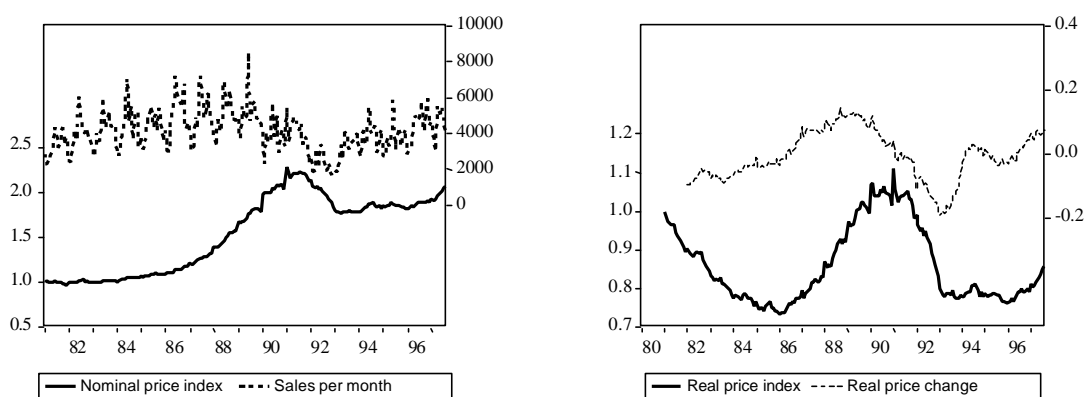
This type of analysis has not been done previously for Sweden but has been published for other countries. Examples of such studies for the American and the British house markets respectively are the analyses of Pollakowski and Ray (1997) regarding the former and Muellbauer and Murphy (1997) and Meen (1997) regarding the latter. They find that price shocks in house prices spread throughout the regions they have studied – the ripple effect.

⁴The set of data has been compiled by Tommy Berger, and the author is indebted to him for this.

Description of the data

The data consists of information from January 1981 to August 1997 for all sales of houses in Sweden. This material, consisting of more than 830 000 observations, has been divided into three big city regions (Stockholm, Gothenburg and Malmö) and four local labour market regions for medium-sized, small and industrial cities, and sparsely populated areas. To obtain a constant quality price index, the reported sales prices were standardised by the assessed value used for tax purposes for each house. Since the assessed value reflects the market value of the house at a specific point in time for all houses, it may be used as an index of housing quality.⁵

Figure 1 Trends in the nominal price level and number of sales of houses (left and right scale respectively in the first figure) and real price level and real price change on an annual basis (left and right scale respectively in the second figure), monthly data 1981:1-97:7 total for the whole country.



The first graph in *Figure 1* shows the price index for the entire country in current prices and the average sales per month. January 1981 has been chosen as the base year for the nominal price index, and from this year the index was mainly unchanged until a few years into the 1980s, and then increased from 1985. The highest value for the nominal price level, 2.27, was registered for January 1991. After this notation,

⁵ The index was constructed as $\Sigma P_{ijt} / \Sigma V_{ijt}$ where P_{ijt} and V_{ijt} correspond to the price and assessed value if the i th house sold in the region j in time period t . See Berger (1997) for a comparative analysis of this type of constant quality house price indexes to indexes based on other methods, such as the hedonic method. For a more general discussion of these issues, see Englund *et. al.* (1999).

prices fall, and the index is noted at 2.05 for the last observation in August 1997. It is also possible to follow monthly sales in the same graph. The average value for the number of sales for the entire period was more than 4000 (see also *Table 1*). The graph shows that it is likely that there is a seasonal component in the time series over the monthly sales. Simple “eye econometrics” also indicates that there seems to be a positive correlation between the price index and the number of sales; there were more transfers during the end of the 1980s when prices increased, and transfers decreased at the time of the fall in nominal prices after 1991.

The second graph in *Figure 1* presents the trend in the real price level together with the annual real price trend.⁶ 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. The real price trend for houses has been discussed previously, and we have concentrated here on studying the change in real prices. The relative change will of course be negative when the real price index shows a negative inclination and vice versa. The graph shows unequivocally that the real price change was negative until 1985 and during the period of 1991 to 94. It was positive in the other periods.

Tabell 1 Mean, minimum and maximum values, standard deviation and coefficient of variation for number of sales, 1981:1-97:7

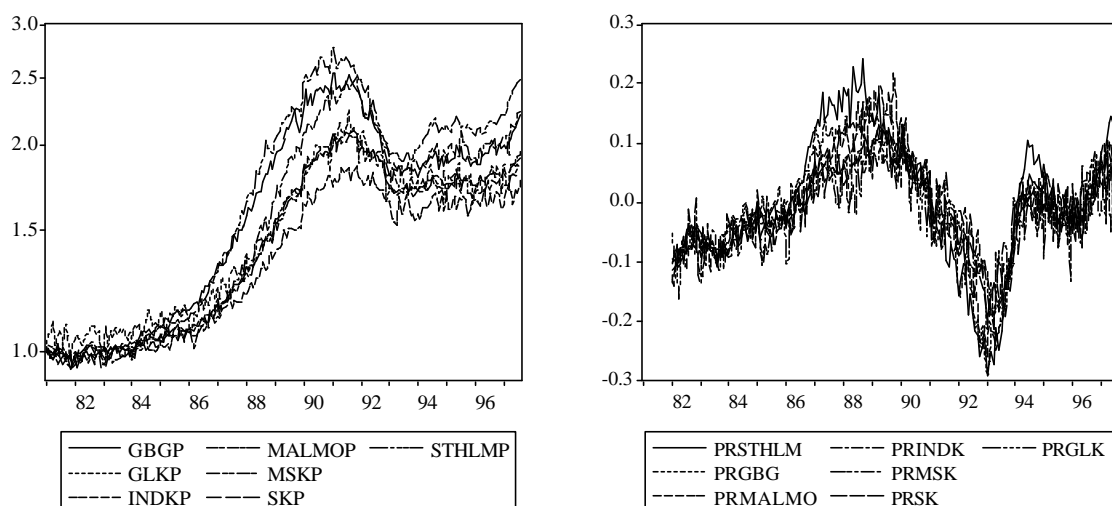
	Large cities			Cities			Spar- sely popu- lated	All re- gions
	Stock- holm	Göte- borg	Malmö	Medium	Small	Indust- rial		
Mean	600	370	325	620	1863	230	155	4163
Max	1084	756	655	1298	3951	521	432	8513
Min	260	110	139	253	748	86	54	1689
Standard deviation	175	109	93	184	547	76	57	1160
Coefficient of variation	0.29	0.29	0.28	0.30	0.29	0.33	0.37	0.28

Both a nominal price index and the real price change are presented in order to illustrate how the seven selected regions covary. This is presented in *Figure 2*. However, before we discuss the prices and price changes of the regions, it can be appropriate to

⁶ Consistently, when relative price changes for house prices are analyzed, we assume that the price level has a stochastic seasonal pattern in that we work with annual differences on the logarithm of the price level. This means that when the relative price change in a variable is generated, this is written as $\Delta_{12}P = \ln P_t - \ln P_{t-12}$, where P represents the price level. We have also tested whether there is any deterministic seasonal pattern in the generated price changes and found that this was not the case.

present the number of sales of house properties in the different regions. The mean, minimum and maximum values, and the standard of deviation and coefficient of variation are presented in *Table 1* which shows that small cities had the highest mean value, sparsely populated regions the lowest, and industrial cities the next lowest. The Stockholm region and the medium-sized cities displayed about the same mean value regarding turnover, while the mean value for the Gothenburg region was greater than that of the Malmö region. The table also shows that the coefficient of variation (the quotient between standard deviation and the mean value) was largely as big or little for the first five categories, higher for industrial cities and highest for sparsely populated cities.

Figure 2 Trends in the nominal price level (the left figure and the logarithmic scale on the horizontal axis) and real price change (annual basis) for big city regions and the four other regional categories for the period of 1981:1-97:7



The Stockholm region showed both the highest mean value and standard deviation. Observe too that only this region shows a positive mean value. The mean value for the other regions was negative, and in one instance equal to zero. The minimum and maximum values in *Table 2* also indicate that the Stockholm region had the greatest dispersion. Statistical tests for normal distribution in real price changes are also reported in the table, and the null hypothesis can not be rejected for any region.

Table 2 Mean, minimum and maximum values, standard deviation, test for normal distribution and test for unit root for real price change, 1981:1-97:7

	Mean	Max	Min	Std dev	JB	DF(8)	PP(8)
Stockholm	0.007	0.273	-0.255	0.112	0.49	-2.27	-1.81*
Göteborg	-0.001	0.192	-0.252	0.095	0.36	-1.85*	-2.03
Malmö	0.000	0.241	-0.228	0.095	0.92	-2.37	-2.37
Medium-sized	-0.012	0.139	-0.186	0.068	0.40	-1.77*	-2.61
Industrial	-0.016	0.119	-0.195	0.061	0.36	-1.96	-4.38
Small	-0.011	0.127	-0.185	0.069	0.35	-2.26	-1.95
Sparsely populated	-0.014	0.137	-0.193	0.071	0.24	-1.71*	-5.81
All regions	-0.007	0.142	-0.193	0.076	0.26	-2.35	-1.81*

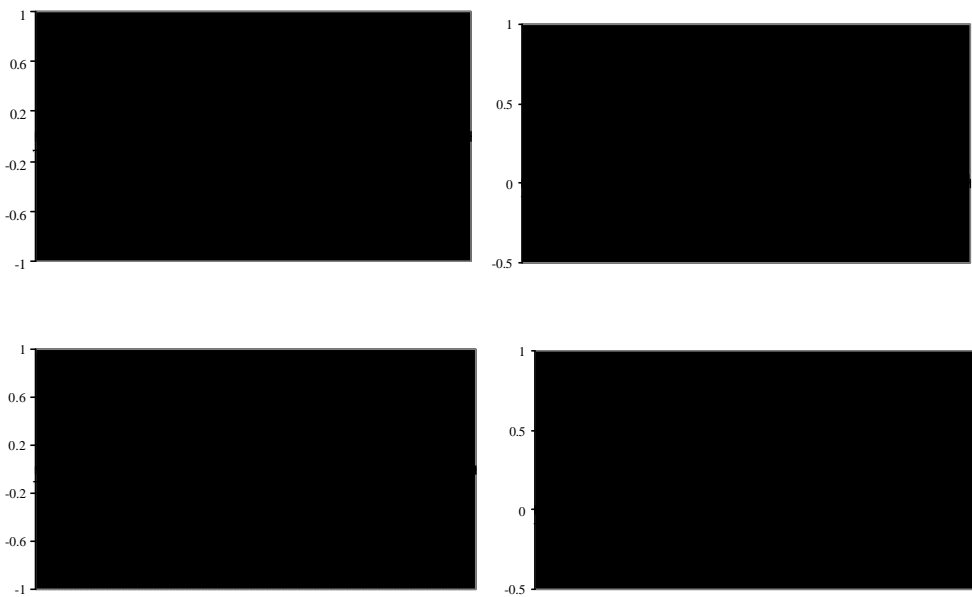
The result of the Jarque-Bera statistical test for normal distribution, JB, is given as a p-value; a value greater than 0.05 indicates that the null hypothesis of normal distribution cannot be rejected on the five per cent level. Critical values for the test for unit root. Dickey-Fuller and Phillips-Peron respectively, on the one per cent level -2.58 and on the five per cent level, -1.90. The Dickey-Fuller test is carried out without a constant and trend and with lagged difference terms up to the 8th order of the price changes. Phillips-Peron is conducted without a constant and truncation lag of eight periods. An asterisk (*) following the test statistic indicates that the null hypothesis of no unit root cannot be rejected on the five per cent level, but on the ten per cent level.

Finally, the test for unit root is reported in *Table 2*. It is important to know whether a time series is stationary or non-stationary (the time series displays a unit root) before a statistical analysis is carried out. If a time series is analysed with an ARMA model, the time series in question has to be stationary. If non-stationary variables are used in regression analysis, many of the standard tests for this analysis will be invalid. The tests that are reported for the existence of non-stationarity are the Dickey-Fuller and the Phillips-Peron tests. The critical values for significance are given below the table. The tests indicate for real price change that the null hypothesis of non-stationarity can consistently be rejected for each of the two tests.

The autocorrelation in the time series for real price change display a high degree of autocorrelation. In order to illustrate this, graphs are presented in *Figure 3* over autocorrelation and partial autocorrelation for the entire country and the Stockholm re-

gion⁷ The graphs over autocorrelation display a pattern that indicates mean reverting, i.e. that an increase in real house prices leads to further increases during about 2 years' time, after which they decrease. After about 7 years, the negative correlation has ebbed out, and the correlation becomes zero. The pattern indicates that the time series can have long memory.

Figure 3 Autocorrelation and partial autocorrelation for real price change up to 86 months for the entire country (the two top graphs) and the Stockholm region



If one studies the graphs over the partial autocorrelations, one finds a “nail” for the first correlation coefficient that is almost equal to one. This can lead one to suspect that there is a unit root in the time series, but our tests in *Table 2* indicate that this is not the case.⁸

The connection between the price trends of the regions

The statistical picture indicates that we have a number of volatile time series in which the Stockholm region displays a high degree of volatility. All the time series are normally distributed and seems to be stationary. This also applies when the time

⁷ One way of testing the existence of autocorrelation is to use the Ljung-Box test. This test finds significant autocorrelation for the 7 years for the country as a whole, the Stockholm region and the other regions.

⁸ A rule of thumb that is often used in time series analysis is that if a time series displays a “nail” in the correleogram for the partial autocorrelation, as the two series to in *Figure 3*, it should be possible to use a AR model to model the trend of the series.

series are aggregated in include the entire country. Consequently, we can use these time series for different kinds of statistical and economic models.

The correlation between the real price change between the seven regions has been high during the period under examination. The lowest correlation coefficient was 0.72 (between industrial cities and sparsely populated areas), but a more normal coefficient between the time series of the regions lands in the interval of 0.85 to 0.90. If the cross correlations between the regions are calculated, these also display long time lags. The data thus displays a high degree of co-variation between the house prices in the different regions, which is also expected and which is shown in *Figure 2*. A question that is interesting in this context is whether the price trend of any of the regions affects or dominates the price trends of the other regions to any great extent. What would seem most natural would be to hypothesise that the Stockholm region is dominating in this respect. As has been mentioned, the English studies have found that the price trend for houses in the London area have been an important explanatory factor for the price trends in other regions and for the price trend in the whole of England (Muellbauer and Murphy 1997). A question that can be asked is if there is a correspondence in Sweden to the so-called South East England effect, or the ripple effect on house prices?

As has been stated, a high correlation exists between the real price changes for the different regions. However, this says nothing about whether or not the prices in the different regions affect each other. One way of analysing the connection between regions is to use the causality test, which has been called the Granger test after its originator. This test does not have anything to do with causality in a deeper sense, but instead tests a variable for content of information. For our concerns, this test can be used to describe, for example, whether the real price change in the prices of the Stockholm region can be used to “explain” or forecast the price change of another region in addition to its own price changes and the previous price changes of that region. In a purely formal manner, the Granger test can be described with the following equation:

$$y_t = C_0 + \sum_{j=1}^k a_j y_{t-j} + \sum_{j=1}^k b_j x_{t-j} + e_t \quad (1)$$

Let the variable y in the equation (1) stand for the real price change in a region, and variable x for that of another region. C_o and all \mathbf{a}_j and \mathbf{b}_j are parameters that are to be estimated. A first step is to estimate the above equation for a given time lag (k) for the variables, and then in a second step to test whether $\mathbf{b}_1 = \mathbf{b}_2 = \dots = \mathbf{b}_k = 0$. If all \mathbf{b} -parameters are not significantly separated from zero, the x variable will not affect the y variable. This is commonly called the null hypothesis, and is usually expressed as x does not Granger cause y .⁹ We have tested for Granger causality between the price changes for the different regions with time lags of a month ($k=1$), a quarter ($k=3$), half a year ($k=6$), 9 months ($k=9$) and one year ($k=12$). The results are shown in *Table 3* where an S indicates a significant effect of a variable, i.e. that the null hypothesis has been falsified.

How should *Table 3* be read? We choose to start at the top of the table for the test with one month's time lag and for the line for the Stockholm region, which is then followed across. The line displays only S's, which means that the null hypothesis is falsified, and that according to the test, the Stockholm region Granger causes each of the other regions. This fact applies regardless of the length of the time lag chosen in the variables, up to 12 months, which can be seen if the different lines for Stockholm are successively followed down through the table.

⁹ This test can be carried out with a number of different statistical tests such as the *Wald* test, the *F* test, the *LM* test and the *Log likelihood ratio* test. We have chosen the last-mentioned test for purely technical programming reasons. The strategy has been to estimate both the equation (1) as it is formulated above without restriction and with the restriction that all \mathbf{b} -parameters are equal to zero. From the difference between the estimates' *log likelihood* value for the two equations, the above null hypothesis can be tested.

Table 3 *Granger causality test of real price change on the selected regional division for different time lags of the variables. An S in the table indicates a significant effect of a variable*

	Stock- holm	Göteborg	Malmö	Medium	Industrial	Small	Sparsely populated
<u>One month</u>							
Stockholm		S	S	S	S	S	S
Göteborg	S		S	S	S	S	S
Malmö		S		S	S	S	S
Medium-sized			S		S		S
Industrial			S	S			S
Small		S	S	S	S		S
Sparsely pop.			S	S	S		
<u>One quarter</u>							
Stockholm		S	S	S	S	S	S
Göteborg			S	S	S	S	S
Malmö				S	S	S	S
Medium-sized	S	S			S		S
Industrial	S	S	S	S			S
Small		S	S	S	S		S
Sparsely pop.				S	S		
<u>Half year</u>							
Stockholm		S	S	S	S	S	S
Göteborg			S	S	S	S	S
Malmö	S	S		S	S	S	S
Medium-sized		S	S		S		S
Industrial		S	S	S			S
Small		S	S	S	S		S
Sparsely pop.				S	S		
<u>9 month</u>							
Stockholm		S	S	S	S	S	S
Göteborg	S		S	S	S	S	S
Malmö	S	S		S	S	S	S
Medium-sized		S	S		S		S
Industrial		S		S			S
Small		S	S	S	S		S
Sparsely pop.		S	S	S	S		
<u>1 year</u>							
Stockholm		S	S	S	S	S	S
Göteborg	S		S	S	S	S	S
Malmö	S	S		S	S	S	S
Medium-sized		S	S		S	S	S
Industrial			S				
Small	S	S	S	S	S		S
Sparsely pop.			S	S	S		

Note. Significant variables indicated by an S mean that the p value for the Granger causality test is less than 0.05.

If, for example, the Gothenburg region is studied, and with a month's time lag, the conclusion is that this West Coast metropolitan area Granger causes each of the other regions including the Stockholm region. If we increase the time lag to a quarter and half a year respectively, the above conclusion remains for Gothenburg if Stockholm is excluded. Correspondingly, the null hypothesis not falsified regarding the Malmö

region for the Stockholm region at a one month and one quarter time lag. Thus, the Malmö region does not Granger cause the Stockholm region, but for the other regions, the Malmö region falsifies the null hypothesis. If a time lag of up to one quarter is allowed, the null hypothesis holds not only for the Stockholm region but also for the Gothenburg region. Medium sized and industrial cities falsify the null hypothesis vis-à-vis the Stockholm region with a time lag of one quarter.

Industrial and small cities and sparsely populated areas did not falsify the null hypothesis vis-à-vis the Stockholm region, with two exceptions for different time lags for the variables. The other regions sometimes had a significant effect and sometimes not. The picture is somewhat fragmented, and the main impression of the test put forward seems to be that the Stockholm region was the region that most clearly falsified the null hypothesis vis-à-vis all other regions.

The information content in the real price changes for houses on the second-hand market can thus be used when price trends in the other regions are to be “explained” or forecasted. The conclusion that we are prepared to draw from the statistical test is that the Stockholm region seems to have the same effect on the price trend for houses in the rest of Sweden as the London region has for the rest of England.

House prices and macro variables

The Stockholm region thus seems to be ahead regarding price trends compared to the other regions, and the test in the previous section indicates that price impulses from the Stockholm area can be said to spread throughout the country. There may be several reasons for this, but it is probably important that upward and downward economic trends are first manifested in the Stockholm area. In this section, where the information content in a number of macro variables are analysed vis-à-vis the price trends for houses, we have chosen to do this only for the Stockholm region and have aggregated for all regions. The reason for this strategy is that the Stockholm region seems “to lead” regarding the real trend of house prices. The same analysis is made for the real price trend for all of Sweden, but not for the other regions.

Table 4 *Granger causality test of real price change for the Stockholm region (upper part of the table) and the country as a whole, with time lags from one month to a year for a number of financial and real macro variables. An S in the table indicates a significant effect of a variable.*

	Relative change			Absolute change			Term premium	Relative real change		
	New order.	Indust. prod.	New cars	Unemp-loyment	Interest rate 3 month	5 years		M0	M3	Stock prices
1			S		S	S	S	S	S	S
2	S		S		S	S	S	S	S	S
3	S		S		S	S	S	S	S	S
4			S		S	S	S	S	S	S
5			S		S	S		S	S	
6		S	S		S	S		S		S
7		S	S		S	S		S		S
8		S	S		S	S		S		S
9		S	S		S	S		S		S
10		S	S		S	S		S		S
11		S	S		S	S		S		S
12		S	S	S	S	S		S	S	S
1	S	S	S		S	S	S	S	S	S
2	S		S		S	S	S	S	S	S
3	S	S	S		S	S	S	S	S	S
4					S	S	S	S	S	S
5					S	S		S	S	
6		S			S	S		S	S	
7		S			S	S		S		S
8		S			S	S		S		S
9		S			S	S		S		S
10		S			S	S		S		S
11		S			S	S		S		S
12		S		S	S	S		S		S

* *Affärsvärlden's Generalindex*, which is a broad stock market index designed to measure the market performance of the Stockholm Stock Exchange (SSE)

Note. Significant variables indicated by an S mean that the p value for the Granger causality test is less than 0.05.

The statistical tests in this section are also made with the Granger test, but now not only with a bivariate test but also with a multivariate test. The first type of test, the bivariate one, is equivalent to the previously discussed test in accordance with equation (1), but with the difference that the \mathbf{x} variable is now constituted by a macro variable. The multivariate test is built on several independent variables – with a given time lag - being incorporated into equation (1), after which the estimated parameters are tested variable by variable to see if these are significantly separated from zero or not.

The financial and real macro variables that have been used in the analysis are shown in *Table 4*. It should be pointed out again that monthly data has been used, and many of the real macro variables that would be desirable to use in the analysis are only available on a quarterly frequency. Information, for example, about household disposable income, consumption and wealth is not available on a monthly basis. Aggregated financial variables such as interest rates and liquidity variables are available on a monthly basis, which also applies to asset prices for shares and consumer prices. This is also true for some of the real variables, such as unemployment and the industrial production index.

A number of “proxy” variables have been used due to the lack of data for certain real variables. Time series over new orders for industry, the industrial production index, new registrations of private automobiles, and unemployment are all variables that reflect real economic trends and could be used as “proxies” for household income expectations.

The interest rates that are used in the analysis are both the three-month interest rate for treasury bills and the five-year interest rate for the government bond loan. The term premium is defined as the difference between the long and short-term interest rate. Both the narrow definition of the supply of money MO and the broader definition M3 have been used as liquidity variables.¹⁰ *Affärsvärldens Generalindex* is used in order to reflect the trend in share prices. Interest rates, liquidity and price trends for shares might be variables that are important for household expectations and decision making.

The bivariate test

The results of the Granger test for macro variables and house prices are presented in *Table 4*. A result that deserves to be commented on first is that the interest rate change Granger causes real price changes in house prices for the Stockholm region and the country as a whole, regardless of the time lag period, at least up to 12 months. This result is in harmony with the fundamental price theory for properties; the price or current value of a property is made up of the discounted value of the fu-

¹⁰ MO is defined as the public’s possession of bank notes and coins. M3 is defined as MO plus the public’s loans in banks and possession of bank certificates.

ture cash flow the property generates. A change in interest rates thus theoretically affects the price, which our results indicate.

On the other hand, the term premium falsified the null hypothesis only for a time lag of up to 4 months, not more. In the macro analyses, we see the difference between long and short-term interest rates as an expectation variable for the general economic trend. The argument is the following: if the market believes in an upward swing in the economy, this means that demand will increase, which presses prices in the economy upward, and thus long-term interest rates. A positive marginal between long and short-term interest rates thus indicates an anticipated upswing in the economy, and a negative marginal indicates a downward swing.

The variable MO falsifies the null hypotheses regardless of time lag for the Stockholm region as well as the entire country. The broader defined liquidity variable M3 does not falsify the null hypotheses in the same unequivocal manner as MO. The change of share prices in real terms seems unequivocally to have information content regarding house price changes in the Stockholm region and in the main for the country as a whole.

If we look at the first four variables in the table, which are of a more real character, the results of the test are varied. The change in unemployment, with one exception, falsifies the null hypothesis. New car registrations tends to falsify the null hypothesis for the Stockholm region, but the picture is unclear for price changes for the entire country. In order for changes in industrial production to falsify the null hypothesis, time lags in the variables are needed of at least 6 months for the Stockholm region. The variable, order intake for industry, seems to have an effect only for some individual months.

The multivariate test

When modelling with the Granger test, when many independent variables have been incorporated, we have experimented with the different macro variables that have been used in the bivariate test. Including all these as right hand side variables in one and the same model will probably result in several of these variables not being significant as a result of *inter alia* the multicollinearity that exists between these macro variables. The strategy instead has been to use a limited number of macro variables,

which based on economic reasons, can be regarded as capturing, for example, income expectations and other factors that affect house prices on the second-hand market. By doing so, after a certain amount of experimentation, we have arrived at the set of variables that are presented in *Table 5*.

Industrial production new car registration and unemployment are variables from the real sphere of the economy, which should be of importance for household income trends and expectations. As already has been mentioned in connection with the bivariate test, the price of a property is anticipated to change with the interest rate; real after tax interest rates are used to test for this effect. MO has been used as a liquidity variable (the M3 variable was never significant). This variable and the interest rate variable were the financial variables that were used. The term premium and the stock prices, which in themselves can be seen as financial variables, are regarded in this context as expectation variables regarding the economic trend. Share prices ought to reflect the market's assessment about future economic trends.

The results of the multivariate test indicate that the liquidity variable that was used, MO, never rejected the null hypothesis, while the share index rejected this hypothesis when the time lag exceeded one month for both price series. The opposite applies to the short-term real after tax interest rate; the null hypothesis is rejected only when there was a time lag of one period. The same thing applies for the unemployment variable for the short-term interest rate for the Stockholm region. For the entire country, on the other hand, the null hypothesis was rejected when there was a 12 month time lag. Industrial production and new car registration also reject the null hypothesis for the longest time lag for both price variables. The only variable in the multivariate test that rejected the null hypothesis for both price series and for all periods with different time lags was the term premium.

In the tests that have been made, it thus can be seen that the information content in both the term premium as well as the share prices seems to be important for house price trends in both the Stockholm region and for the entire country. This would appear to be reasonable based on a purely theoretical starting point, since we see these two variables as being important when households form their expectation about the future. The information content in industrial production and new car registration vis-à-vis the price variable does not become visible until the longest time lags in the

variables. Note that the same applies to the unemployment variable for the entire country, while for the Stockholm region and unemployment, the null hypothesis is rejected only when the time lag was one month.

Table 5 The Granger causality test of the real price change for the Stockholm region and the entire country (dependent variable) and a number of macro variables with the length of the time lag from 1, 3, 6, 9 and 12 months. An S in the table indicates a significant effect of a variable

<u>Stockholm</u>	1	3	6	9	12
Industrial production					
New cars				S	S
Unemployment	S				
3 month real interest rate after tax	S				
Term premium	S	S	S	S	S
Real M0					
Real AFGX		S	S	S	S
<u>All regions</u>					
Industrial production					S
New cars					S
Unemployment					S
3 month real interest rate after tax	S				
Term premium	S	S	S	S	S
Real M0					
Real AFGX		S	S	S	S

Note. The first and last two variables are expressed as relative 12-month changes. Unemployment and short-term real interest rates after tax are expressed as 12-month differences. The term premium is calculated as the interest rate difference between the 5-year government bond and the 3-month treasury bond.

The vector autoregressive model

Previous studies have shown that different real and financial variables are important explanatory factors for price change on the second-hand market for houses, and our results confirm these findings.¹¹ In this section, we will try to deepen the analysis by using a model that simultaneously takes into consideration changes in real house prices for the Stockholm region, relative changes in the new registration of cars, and changes in unemployment. This model also includes a number of exogenous variables that we will return to.

The basis for the model is the economic theory and intuition that households plan consumption based *inter alia* on wealth expected future real interest rates and income (the life cycle theory). Changes in house prices, consumption and unemployment are

endogenous and affect each other. Thus house price changes will be of importance for household wealth trends as well as consumption and employment. Consumption changes ought to affect employment, and perhaps more indirectly house prices, while unemployment is directly expected to have an effect on house prices and consumption. Another way of expressing these connections is that changes in house prices and unemployment can be seen as “proxies” for household expectations regarding income and wealth trends thus indirectly affecting consumption trends.

Thus the variables that are necessary to carry out the analysis are changes in house prices, consumption and unemployment. We have only analysed the Stockholm region, which means that it would be desirable to have regional time series for this region; something we only have for house prices. We have worked with monthly data. Household consumption is only available on a quarterly basis. It is not available either on a monthly or regional basis for the Stockholm region. Therefore, new registration of private cars has been chosen as a “proxy” for consumption. The chosen consumption “proxy” is strongly correlated with consumption trends for the entire country.¹²

The exogenous variables included in the model have been chosen based on theoretical considerations and a certain amount of experimentation. The exogenous variables that have been chosen are short-term real interest rates after tax, term premium, the relative change in the share index, and the relative change in new orders for industry. The exogenous variables have been specified with a certain variation in time lag as the same time as the time lag for the three endogenous variables is 5 months.

The model we have used is usually termed vector autoregressive, VAR. In a mathematical form, the VAR model can be written in vector form, as equation (2) where \mathbf{y} and \mathbf{x} respectively represent vectors of endogenous and exogenous variables respectively. \mathbf{A} and \mathbf{B} are coefficient matrices that are to be estimated, and \mathbf{e} is a vector for random error, or innovations. These innovations are of course uncorrelated with the respective right hand variables in the respective equations, but are probably correlated between the equations.

¹¹ See Englund *et al* (1995) and Hort (1997).

¹² The correlation coefficient between the relative change in new registration of private cars and the relative change in consumption expenditures, durable and non-durable consumption goods was 0.82, 0.98 and 0.85 respectively for the quarterly data, 1981:1-97:2.

$$\mathbf{y}_t = \mathbf{A}_1 \mathbf{y}_{t-1} + \dots + \mathbf{A}_N \mathbf{y}_{t-N} + \mathbf{B}_1 \mathbf{x}_{t-1} + \dots + \mathbf{B}_N \mathbf{x}_{t-N} + \mathbf{e}_t \quad (2)$$

In our case, the system consists of three equations. The endogenous variables in the \mathbf{y} -vector consist of the changes in real house prices in the Stockholm region, new car registration, and the change in unemployment. In addition to a constant, the four above-mentioned exogenous variables are included in the \mathbf{x} -vector. The equation system has been estimated for the period of 1982:6 – 97:07 and the result is presented in appendix *Table A1*.

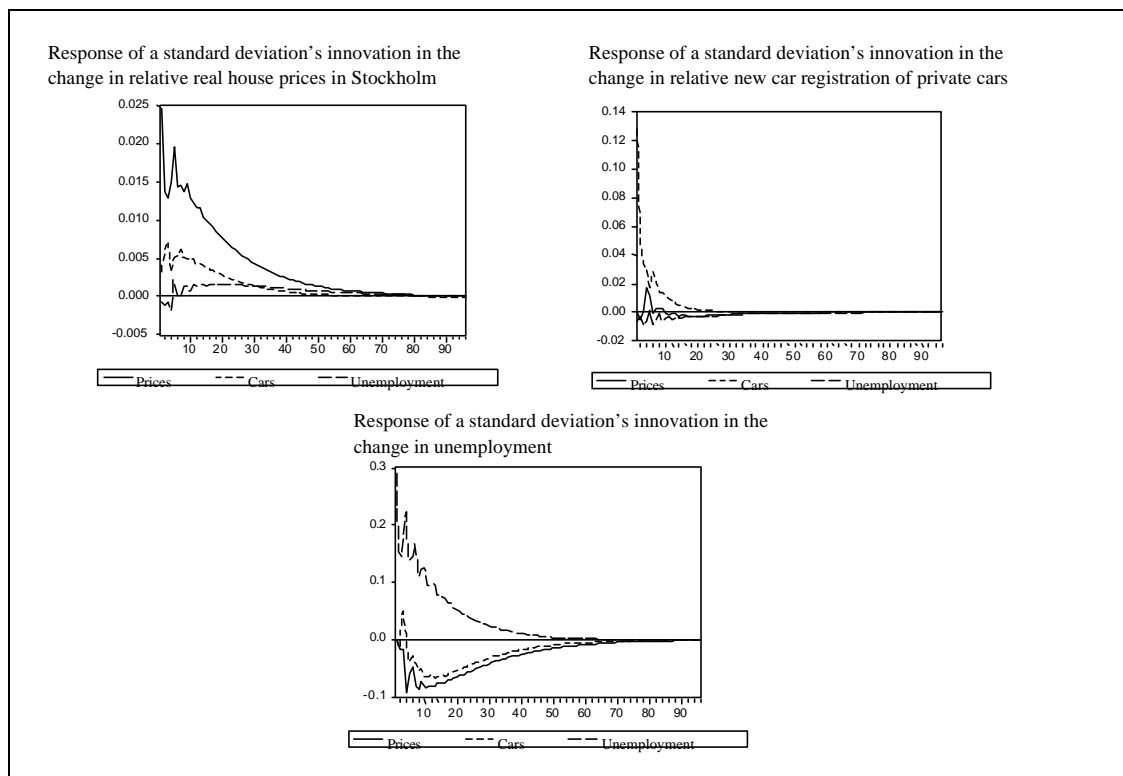
The technique with VAR models is usually used in connection with forecasting, and this method is especially suitable when the system only consists of endogenous variable. Our purpose, however, is not to forecast the three endogenous variables, but instead to study the co-variation between these and the stability in the system. For this purpose, it is customary to use impulse response functions in the VAR system. An impulse response function traces the effect of a shock to one of the innovations on current and future values of the endogenous variables. If these three innovations are uncorrelated with each other, the interpretation of the impulse-response functions will be simple and uncomplicated.

$$\begin{aligned} y_t^1 &= \sum_{i=1}^5 \mathbf{a}_i^{1,1} y_{t-i}^1 + \sum_{i=1}^5 \mathbf{a}_i^{1,2} y_{t-i}^2 + \sum_{i=1}^5 \mathbf{a}_i^{1,3} y_{t-i}^3 + \text{Exogenous var} + \mathbf{e}_t^1 \\ y_t^2 &= \sum_{i=1}^5 \mathbf{a}_i^{2,1} y_{t-i}^1 + \sum_{i=1}^5 \mathbf{a}_i^{2,2} y_{t-i}^2 + \sum_{i=1}^5 \mathbf{a}_i^{2,3} y_{t-i}^3 + \text{Exogenous var} + \mathbf{e}_t^2 \\ y_t^3 &= \sum_{i=1}^5 \mathbf{a}_i^{3,1} y_{t-i}^1 + \sum_{i=1}^5 \mathbf{a}_i^{3,2} y_{t-i}^2 + \sum_{i=1}^5 \mathbf{a}_i^{3,3} y_{t-i}^3 + \text{Exogenous var} + \mathbf{e}_t^3 \end{aligned} \quad (3)$$

If the system is “shocked” with an innovation that corresponds to a standard deviation of the endogenous variable in question, the impulse-response function is used to study the effect of this shock on all three of the endogenous variables. If, for example, we chose this is thus the innovation for the changes in house prices. In the first period only the house prices will be affected when the endogenous variables are included with time lags in the equation system. In the next period all three equations will be affected since the trend in house prices with one period’s time lag will be included in all the equations. The impulse response function makes it possible to study the development of the system of equations – what variables are affected by which shock, if it is moving towards a new equilibrium, and in that case how long it will

take. This procedure is repeated for each of the endogenous variables.¹³ The results of the experiment with the model are presented in *Figure 4*.

Figure 4 Response impulse graphs over a standard deviation's innovation in each of the three endogenous variables in the VAR model.



The impulse-response exercises show that shocks from the “consumption proxy” that has been used does not affect changes in house prices and unemployment – see the first line of the right-hand graph in *Figure 4*. On the other hand, a shock in the change in house prices has a clear effect on the “consumption proxy”, but no effect on the change in unemployment – the first line of the left-hand graph. A shock in the change in unemployment, on the other hand, decreases the real change in house prices and the change in new car registration – the bottom graph.

The “consumption proxy” used does not seem to have any information content for the tow other endogenous variables, since a shock in this variable does not affect the others. A shock in the real change in house prices has a positive effect on the “consumption proxy”, which can be interpreted as a wealth effect; a real increase in house

¹³ As was mentioned earlier, the interpretation of the impulse-response functions will be simple and uncomplicated if the innovations are uncorrelated with each other. However, if these are not independent of each other, this means that these have a common component that cannot be identified. See e.g. Charemza and Deadman (1997) for a discussion of this problem.

prices increases household wealth, which in turn affects consumption. In our previous discussion, change in unemployment has been seen as a proxy variable for household income expectations. If this interpretation is reasonable, a negative shock in expectations about future income (increased unemployment) will have strong effects on both house prices and consumption. It can also be noted that the effect of the shock will be temporary, but the adaptation towards equilibrium will be a long drawn out process, and it can take 4-5 years to reach the new level of equilibrium.

Conclusion

This essay analyses trends in house prices on the second-hand market. The set of data consists of monthly data from January 1981 to July 1997 and has been divided into three big city regions (Stockholm, Malmö and Gothenburg) and four local labour market regions (medium-sized, industrial, and small towns, and sparsely populated areas). The statistical test indicates that the real prices change for the Stockholm region has information content for all the other regions with a time lag of up to one year. The Stockholm region seems unequivocally to “lead” the price changes on the house market, an effect that corresponds with the effect the London region has on the British house market - the ripple effect.

Our test of the real price changes in the Stockholm region and a number of real and financial macro variables shows that these variables had information content or “explanatory value”. In this context, real interest rates after tax, term premium (the difference between long and short-term interest rates), stock prices, industrial production and a “proxy variable” for consumption trend were important factors. A simple VAR model with change in real prices in the Stockholm region, the “consumption proxy” and the change in unemployment as dependent variables and a number of exogenous variables has been estimated. The experiment with the impulse response functions indicates *inter alia* that a shock in unemployment produces a strong effect on house prices and consumption, and that adaptation towards a new equilibrium takes 4-5 years. Unemployment, which in this context can be seen as a variable that reflects household future expectations, is thus of importance for the trend in house prices and private consumption.

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Table A1 *Estimated VAR model, 1982:6-97:7*

	Prices Sthlm	New cars	Unemployment
Sthlm price (-1)	0.56 (7.00)	-0.22 (0.54)	-0.64 (-0.69)
Sthlm price (-2)	0.21 (2.35)	0.22 (0.48)	-0.03 (-0.03)
Sthlm price (-3)	0.20 (2.21)	0.69 (1.52)	-2.83 (-2.74)
Sthlm price (-4)	0.19 (2.15)	-0.19 (-0.41)	1.99 (1.90)
Sthlm price (-5)	-0.21 (-2.66)	-0.62 (-1.51)	0.83 (0.89)
New cars (-1)	0.03 (1.99)	0.38 (4.79)	-0.10 (-0.58)
New cars (-2)	0.01 (0.85)	0.12 (1.44)	0.52 (2.69)
New cars (-3)	-0.03 (-2.10)	0.07 (0.76)	-0.15 (-0.79)
New cars (-4)	0.00 (0.10)	-0.03 (-0.38)	-0.35 (-1.85)
New cars (-5)	0.00 (0.26)	0.13 (1.56)	-0.12 (-0.66)
Unemployment (-1)	0.00 (0.20)	0.00 (0.13)	0.52 (6.50)
Unemployment (-2)	0.00 (0.20)	-0.02 (-0.59)	0.23 (2.72)
Unemployment (-3)	0.00 (0.51)	0.01 (0.22)	0.37 (4.54)
Unemployment (-4)	0.02 (2.21)	0.03 (0.81)	-0.24 (-2.90)
Unemployment (-5)	-0.01 (-1.63)	-0.02 (-0.72)	0.02 (0.28)
Constant	0.00 (1.00)	-0.01 (-0.57)	0.10 (2.88)
3 month real interest rate after tax (-1)	-0.01 (-1.77)	-0.13 (-3.02)	0.11 (-1.13)
3 month real interest rate after tax (-2)	0.02 (1.62)	0.16 (3.24)	-0.26 (-2.42)
3 month real interest rate after tax (-3)	0.01 (1.29)	0.08 (1.73)	-0.01 (-0.09)
Term premium (-1)	0.00 (0.56)	-0.01 (-0.55)	0.03 (0.83)
Term premium (-2)	0.00 (-0.86)	0.02 (1.67)	0.01 (0.35)
AFGX(-1)	-0.02 (-1.12)	-0.02 (-0.21)	0.18 (0.80)
AFGX(-2)	0.02 (0.80)	0.10 (0.70)	0.01 (0.04)
AFGX(-3)	0.01 (-0.52)	-0.05 (-0.45)	-0.34 (-1.48)
New order	-0.01 (-0.15)	-0.08 (-0.44)	-0.91 (-2.09)
New order (-1)	-0.01 (-0.39)	0.25 (1.32)	0.24 (0.57)
Adj. R-squared	0.9430	0.6127	0.9145