STOCKHOLM SCHOOL OF ECONOMICS
Master's thesis within International Economics
Fall 2009

Tutor: Hans Tson Söderström
Dissertation: September 1ST 2009
Discussant: Henrik Storm Dyrssen

The predictive power of price dynamics

- The causality between house prices and stock prices in Sweden 1992-2009

Abstract

We examine whether a causal relationship exists between the prices of households' two major assets; stocks and houses. In particular we study the causal impact and the direction of causality between these two asset types during the period 1992q1-2009q1 in Stockholm and in Sweden as a whole. We argue that a causal relationship should be present since households are financially affected by changes in these price series and thereby choose consumption and investment accordingly. By conducting a granger-casualty test controlling for the GDP and the interest rate, we find a positive unidirectional causal relationship running from the stock market to the housing market with a time lag of one year both in Sweden and in Stockholm. Moreover, an in-depth analysis shows that the causal effect is larger and more persistent in Stockholm than in Sweden as a whole. A 10 percent increase in stock prices has a positive impact on house prices after one year with approximately 1.3 and 2.8 percent for Sweden and Stockholm respectively. We conclude that these results are not only important for households but also for policy makers concerned with financial stability. Our findings stress the importance for creating a tool for households to hedge against house price fluctuations.

Keywords: Granger, Causality, House, Stock, Price, Household, Tobin's Q

Linn Bergström

Registration number 21425

Emy Holstenson

Registration number 20602

Acknowledgements: We would sincerely like to thank our tutor Hans Tson Söderström for the support and guidance during the process of writing this thesis. We would also like to thank Rickard Sandberg for his expertise and technical advice.

Table of Contents

1 Introduction

The purpose of this thesis is to increase the understanding of the relationship between the prices of households' two major assets in Sweden; stocks and houses. Over time, both positive and negative relationships between the price series have been observed. For example, periods with large capital inflows to equity markets have experienced reduced investment in houses, which have led to lower house price appreciations (Sutton 2002). Similarly, equity losses have been offset by increases in property prices. These observations imply a negative relationship between stock and house prices. On the other hand, history also shows that over long time periods these price series move together (Kakes, van 2004) which instead implies a positive relationship between the assets.

Over recent decades movements in house and stock prices have played a central role in the most pronounced financial cycles. In the current financial crisis, changes in stock and house prices have been a key focus of public debate. Given the proliferation of complex structured collateralised products, with mortgages bundled together into investment products, the housing market in the US has had a major impact on global stock markets and created the deepest recession since 1929. In Sweden the median value of the households' stock market portfolio was halved from 2007q4-2008q4 (Statistics Sweden 2009b). The house prices of one and two family dwellings in Sweden also decreased in late 2008 and in the beginning of 2009 for the first time since 1992-93. These recent events suggest a positive causal relationship between the stock market and the housing market. Causality in this sense implies a relationship between one event (called cause) and another event (called effect), which is a direct consequence of the first. Hence, the past value of one variable explains the present value of another variable. If a causal relationship between stock and houses is detected, this entail that the leading variable can be used as an indicator of how the other variable will develop. Therefore, determining the potential effect and time lag of the causal relationship is of interest, especially today due to the large fluctuations in the stock market.

The research question we attempt to answer is:

- Is there a causal relationship between stock prices and house prices in Sweden and Stockholm between 1992 and 2009? And if so, what are the direction and impact of causality between the asset types?

1.1 Organization of the thesis

This thesis will be organized as follows. In section 2 the background on household exposure to the stock and housing markets and the development of stock and house prices over time is presented. In section 3, the theoretical framework is reported and consequently, the hypotheses are developed. In section 4 the methodology is described and in section 5 our data are presented. Finally, the empirical results are reported in section 6, and a discussion of our results is presented in section 7, followed by the conclusion in section 8.

2 Background

In this section the relevant background on the stock and housing markets is presented. In section 2.1 definitions of the markets is reported. In 2.2 the households' exposure to the stock and house markets is explained. In 2.3 the development of the price series over time is presented.

2.1 Definition of the markets

In this thesis, the housing market refers to one and two family houses for permanent living. Hence, multi-family dwellings, flats, land and commercial buildings are not included[1]. The discussion of the stock market refers to the development of stocks registered at the Stockholm stock exchange.

2.2 Households' exposure to the stock and house markets

In Sweden, the total value of the households' ownership of houses and stocks were approximately 3 219 billion SEK and 521 billion SEK respectively in 2007, (Statistics Sweden 2009a). In Sweden about 40 percent of the population lives in one or two family houses (Statistics Sweden 2009a) and 35 percent owns stocks (Statistics Sweden 2004). Moreover, if pension funds are included all Swedish households can be considered to have an indirect ownership of stocks (Barnekow 2002).

According to the Swedish households' balance sheet (*Table 1A*), 41 percent of household wealth is invested in houses and 12 percent consists of direct and indirect ownership of stocks (Statistics Sweden 2009a)[2]. Hence, the combined value of stocks and housing constitutes a large part of households' total wealth.

---

[1] Multi-family dwellings and flats are not included in our study since data on these price series have not been collected before 2003. A further discussion on this can be found in section 7.3.

[2] Excluding pensions and insurance funds that approximately constitutes 38 percent of the households' financial wealth. These are excluded since the distribution of the funds is uncertain according to Statistic Sweden.

Table 1: The households' balance sheet in Sweden (A) and Stockholm (B) in 2007

Table 1A: Household Wealth, Sweden 2007

	Total wealth (bnSEK)	Wealth per person (KSEK)	Total wealth (%)
House	3 219	351	41%
Other real estate	2 503	273	32%
Real assets total	***5 722***	***623***	***73%***
Direct ownership of stocks	521	57	7%
Indirect ownership of stocks	409	45	5%
Other financial assets	1 233	134	16%
Financial assets total	***2 163***	***236***	***27%***
Total assets	**7 885**	**859**	
Net wealth	5 722	623	73%
Debt	2 163	236	27%
Total debt and net wealth	**7 885**	**859**	

Table 1B: Household Wealth, Stockholm 2007

	Total wealth (bnSEK)	Wealth per person (KSEK)	Total wealth (%)
House	839	430	34%
Other real estate	974	499	39%
Real assets total	***1 813***	***930***	***73%***
Direct ownership of stocks	265	136	11%
Indirect ownership of stocks	103	53	4%
Other financial assets	307	157	12%
Financial assets total	***675***	***346***	***27%***
Total assets	**2 487**	**1276**	
Net wealth	1 844	946	74%
Debt	643	330	26%
Total debt and net wealth	**2 487**	**1276**	

Source: Statistics Sweden, Wealth statistics. Note that pension funds and insurances are excluded from the households' wealth.

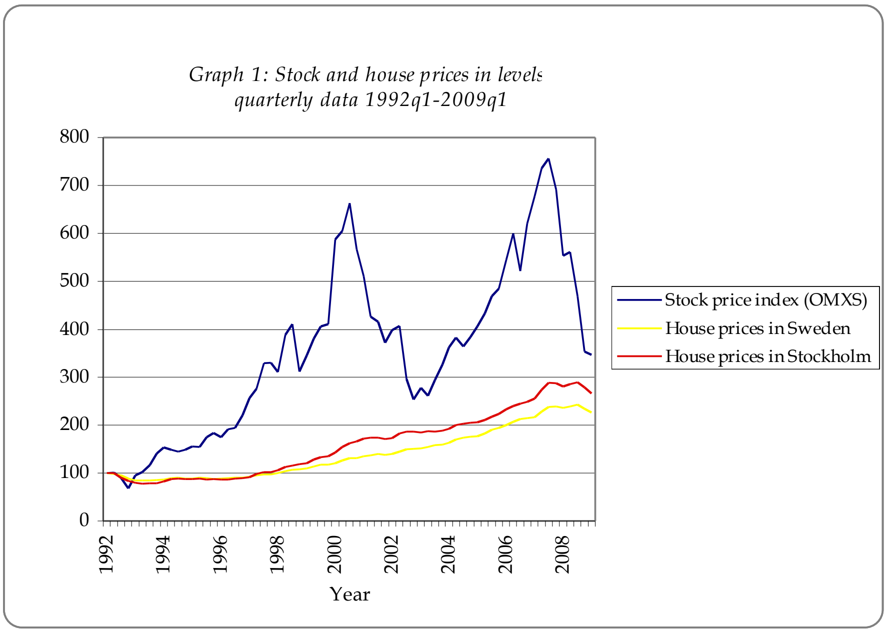
The development of stock and house prices is naturally of interest for households that consider selling their assets. However, perhaps more importantly, these price developments are of great significance for all housholds that hold the assets due to the balance sheet effects. Assuming households want to keep their debt ratio (debt/assets) constant, they would have to compensate for changes in stock or house prices by adjusting their savings and consumption. For example, falling stock or house prices would lead to increased savings and therefore lower levels of consumption (Berg 2002). In this way, variations in both house and stock prices have an impact on the households' saving and consumption behaviour. Household consumption accounts for approximately half of Sweden's total consumption (Nyberg 2005-12-19) and therefore these changes in asset prices are likely to significantly affect the Swedish economy as a whole.

The likelihood of a relationship between stock and house prices is especially large in wealthier areas where a greater share of the households owns both stocks and houses. In Sweden there are big differences in wealth between different geographical regions. Seven of the ten richest municipalities in the country are located in the Stockholm county. According to the households' balance sheet for the Stockholm county *(Table 1B)* the net wealth per person is higher in Stockholm than in Sweden as a whole, with 950 thousand SEK in Stockholm and 620 thousand SEK in Sweden. Moreover, the ownership of stocks per person is almost double in Stockholm than in Sweden, with an average of 189 and 102 thousand SEK respectively (see *Table 1A and 1B*, the sum of direct and indirect ownership of stocks excluding pensions). It is also more common for households in Stockholm to own their private dwelling (Statistics Sweden 2004) and the average value of houses is higher in Stockholm than in Sweden, with 430 and 351 thousand SEK per person in Stockholm and Sweden respectively. As a result, households in Stockholm are more likely to become affected financially by changes in stock and house prices than in Sweden, and thereby the price series are more likely to be interconnected in Stockholm.

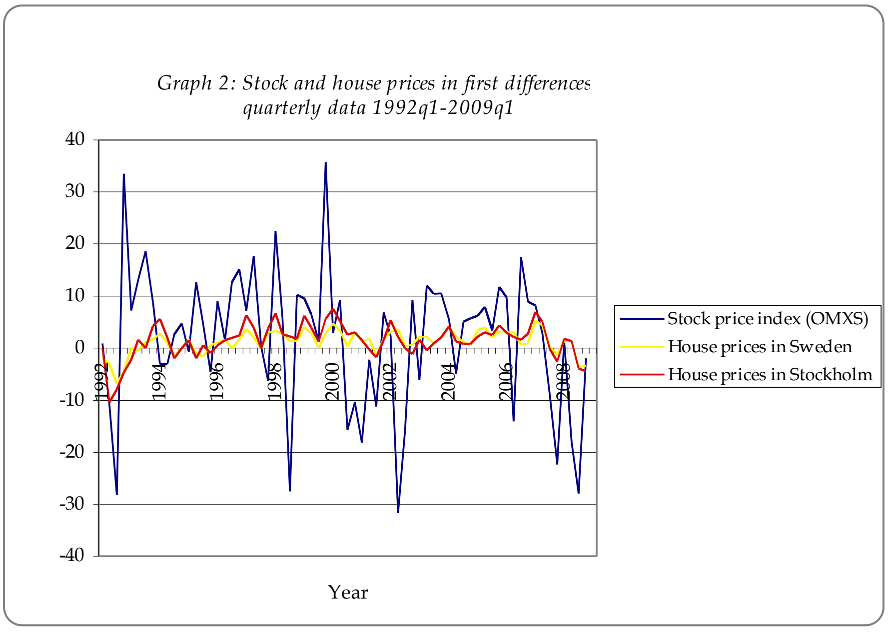
2.3 Development of house and stock prices in Sweden 1992q1-2009q1

The quarterly development of stock and house prices in Sweden and Stockholm are presented in levels in *Graph 1* and in first differences in *Graph 2*[3]. In *Graph 1* we can see that the stock market has had two major peaks and two severe downturns during the period between 1992q1 and 2009q1. The first peak is around year 2000, but after the dotcom-bubble burst a deep downturn took place in 2002-03. The second peak was reached in mid-2007 and was followed by a severe downturn in 2007-08. Furthermore, *Graph 1* shows that house prices trended steadily upwards during this period. However, in the first six observations 1992q1-1993q2 and in the two latest observations, 2008q4 and 2009q1, house prices are falling in both Stockholm and Sweden.

[3] Note that we compare house prices in the Stockholm county to the house prices in the whole country (including Stockholm). Unfortunately we could not remove the effect of Stockholm on Sweden. House prices are measured by the Real estate price index and stock prices by the OMXS index, further described in section 5.3.



Graph 2 shows the development of stock and house prices in first differences, i.e. the quarterly price changes in percent. Here, we see that the volatility of house prices has been larger in Stockholm than in Sweden and that stock prices have larger fluctuations overall than house prices over time. However, by looking at *Graph 1* and *2* we cannot see any clear relationship between the markets, which leaves the question open of what the causal relationship actually looks like.



2.4 Relevance and target group

Causality implies that the past value of one variable adds explanatory power when looking at the present value of another variable. A potential causal relationship between stock and house prices, positive or negative, would indicate that the price series significantly reinforce or soften the effects of each other. A positive causal relationship implies that if one of the variables increases, the other will increase in the following period (holding everything else constant). Similarly a negative relationship would imply that if one of the variables increases the other would decrease in the following period. It is important to determine this potential relationship in order to gain a deeper understanding of households' risk exposure and for assessing their optimal portfolios. If a positive relationship between the assets exists, it might be risky for households to have a large part of their wealth invested in housing and stocks since the value of these assets would move in the same direction. A decrease in prices would then have a significant impact on household wealth.

If a causal relationship between the two variables would be detected, this would entail that the leading variable can be used as an indication of how the other variable will develop, no matter if their relationship is positive or negative. Therefore, determining the potential effect and time lag of the causal relationship is of big interest. Today this relationship becomes especially important and interesting due to the large fluctuations in the stock market; a positive causal relationship could have a severe impact on households' consumption and thereby on the Swedish economy as a whole.

Our findings could also motivate the need for creating a tool for hedging against falling house prices. Most households have unbalanced and highly leveraged asset portfolios and often the house or apartment constitutes several hundred percent of the households net wealth. Through time, many highly leveraged households - both today in the United States and in Sweden during the early 1990s - have witnessed how fast the value of their real estate has diminished. Still today there are no financial instruments or insurance contracts that make it possible for households to hedge against house price fluctuations (Englund 2009). The issue of hedging against falling house prices would become especially important if a positive causal relationship between stock and house prices exists since both these assets constitute a large part of households' total wealth. A tool for hedging against falling house prices would then make it possible for the households to decrease their risk exposure.

Our findings will not only be important for households but also for policy makers in the area of financial stability. The development of asset prices (both houses and stocks) is of vital importance in the Swedish Central Bank's analysis of financial stability. The banks' lending ratio and the risk exposure of households play an important role for financial stability, and the risk exposure is closely connected to the relationship between the stock and house prices. This follows from the fact that a positive causal relationship between the price series would imply that a change in the price of one asset would have greater effect on households' finances since the price of the other asset type change in the same direction, as explained earlier.

An assessment of the causal relationship between stock and house prices is also important for monetary policy purposes. Asset prices have a positive relationship to inflation, hence if asset prices increase inflation is likely to increase. To promote a stable price development, the central bank predicts the asset price development and plans the repo rate path accordingly. For this purpose it is important to be able to foresee the development of asset prices. By investigating the causal relationship between stock and house prices we assess whether any of the price series can be used to predict the development of the other.

2.5 Contribution

Several studies have examined the causal relationship between stock and house prices in other countries but according to our knowledge, there is only one previous study by Berg and Lyhagen (1998) that previously has examined the causal relationship in Sweden. Berg and Lyhagen examine the determinants of house prices in Sweden by studying the causal impact of different macroeconomic variables on house prices, including stock prices, and they reach the conclusion that the stock market granger-causes the housing market in Stockholm but not in Sweden[4]. Berg and Lyhagens' study differs from ours in several ways. First, they look at the period between 1981 and 1997, a time period with different characteristics than ours. Changes in lending policies and rules for subsidies for house owners changed dramatically in the late 1980s, early 1990s. After 1992 the housing market became more market driven and the new market characteristics have important implications for our model (explained further in section 5.1). By excluding the period before 1992 we can better reflect the current conditions that surround Swedish households. Second, Berg and Lyhagens' model of the relationship between stock and house prices is bivariate and does not include any control variables, while we control for the gross domestic product (GDP) and the interest rate. Third,

[4] Granger-causality between two variables implies that the past value of one variable is significant for explaining the present value of the other variable. The definition of granger-causality is developed further in section 4.1.

they use different indices for the stock and house price series compared to the ones applied in this study[5]. Finally, our study also differs from Berg and Lyhagens' study since we conduct an in-depth analysis using an impulse-response function to examine the size and time lag of the causal relationship between house and stock prices. In this sense our study is more profound with respect to the causal relationship between stock and house prices.

Furthermore, according to our knowledge, there is no previous study that has compared the causal size and impact between stock and house prices between urban and rural areas. Moreover, our theoretical discussion adds a new dimension to the understanding of the causal relationship between stock and house prices in urban and rural areas. By applying the investment theory related to Tobin's Q we can add a novel explanation of the differences between geographical areas with respect to the causal relationship between stocks and houses.

[5] Our data is presented in section 4 and a further discussion of our choice of data compared to Berg is presented in section 7.1.

3 Theoretical framework and hypothesis

The first part of this section 3.1, review some theories of the stock and house markets. In section 3.2 theories of the causal relationship between stock prices and house prices are presented. Finally, in 3.3, our hypotheses are developed.

3.1 Theories of the stock and house markets

Theories of the house market

Houses have a dual characteristic since they can be described as both a consumption good and an investment good (Dusansky, Koc 2007). This has important implications for the theoretical reasoning in this thesis. This special feature of the housing market follows from the fact that a house is a real asset to be utilized as a shelter, and simultaneously a house is commonly viewed as an investment vehicle. The house acquisition is also often the largest single investment a household makes over its lifetime (Hort 1998). The dual characteristic is generally more prominent in urban areas where houses are more commonly considered to be an investment good than in rural areas (Kapopoulos, Siokis 2005).

A possible causal impact from stock to house prices depends on the supply elasticity of the housing market. A classical theory for explaining supply and demand for housing is the investment theory of Tobin's Q which states that the construction rate of houses should be related to the ratio between the marginal price and the marginal cost of production (Berg, Berger 2006). The Q theory indicates the state of the market; a ratio where $Q<1$ implies excessive supply of houses, and $Q>1$ implies excessive demand for houses, and $Q=1$ indicates that the market is in equilibrium. If the market is not in equilibrium, e.g. if demand exceeds supply (the marginal price of a house exceeds the marginal cost of producing the house ($Q>1$)), then suppliers construct more houses since the excess demand puts an upward pressure on prices that enables a profit margin for suppliers. According to this approach, the elasticity of supply determines how large the changes in price and quantity will be when housing demand shifts (e.g. from a change in stock prices). Urban areas often have more inelastic supply of houses than rural areas. Therefore, in urban areas, a change in housing demand will induce a smaller change in the rate of construction and a greater house price change than in rural areas. Accordingly, if there is a causal relationship from stock to house prices, this would be stronger in urban areas than in rural.

Theories of the stock market

The efficient market hypothesis states that stock prices are random and unpredictable. This suggests that no causality exists from house prices to stock prices. Since stock prices move randomly around their mean value (follows a random walk) they cannot be predicted by any other variable. All available information that could be used to predict stock performance is already reflected in the stock prices (Bodie, Kane et al. 2005). However, the efficient market hypothesis does not preclude that stock prices affect other markets, such as the housing market.

Another characteristic of the stock market is that it is forward-looking in the sense that stock prices equal the discounted value of future expected earnings. Stock market prices can be seen as a predictor of future economic activity and hence also the development of house prices (Berg, Lyhagen 1998).

3.2 Theories on the causal relationship between stock and house prices

The wealth effect

One of the fundamental assumptions in economic theory is that consumers strive to maximize their utility. Utility is assumed to be a function of current and future aggregate consumption. Households maximize their utility subject to their budget constraint; current and future earnings over their lifetime plus net wealth (Ando, Modigliani 1963). As a result, households' consumption is an increasing function of total wealth (Blanchard, Quah 1989, Chen 2001). Hence, increased stock and house prices (implying higher wealth) should lead to increased consumption via the wealth effect. The increased consumption can partly be enabled by expanded borrowing as the value of the households' collateral increases. The increased consumption would concern all goods and services; including houses (here considered as a consumption good) with a resulting increase in house prices. Moreover, the increased demand for goods and services have a positive impact on stock prices since company earnings would rise and thereby increase the expectations of future dividends (Kapopoulos, Siokis 2005). In this way the wealth effect predicts a positive relationship between the two markets: an appreciation of stock or house prices would have a positive impact on the other market and similarly, a depreciation would have a negative impact.

The wealth effect would only appear as a result of unexpected gains in wealth according to the life cycle hypothesis developed by Ando and Modigliani (1963). The life cycle hypothesis builds on the assumption that households smooth consumption over their lifetime, which mean that predicted gains in wealth should already have been accounted for and smoothed out by previous lending/borrowing and would therefore not have an impact on consumption. Hence, according to this theory, the wealth effect will only have an impact on consumption if the changes in wealth are unanticipated (Green 2002). Similarly, the permanent income hypothesis states that temporary changes in asset prices do not affect the consumption behavior of households, since they do not affect the households' lifetime wealth (Hall 1978). According to the efficient market hypothesis, asset prices are unpredictable. This also implies that changes in asset prices are seen as permanent. Hence, the wealth effect will have an impact. Even if efficient markets are violated in the sense that changes in asset prices are anticipated and only temporary there might be an impact on consumption since households' preferences often entail a bias towards spending today rather than in the future. This is referred to as a time inconsistent behavior, and predicts that also temporary and anticipated changes in asset prices generate a positive causal relationship between stock and house prices through the wealth effect (Rothbard 2008).

Portfolio theory

When considering houses as an investment good, modern portfolio theory (e.g. Markowitz (1952)) is applicable for analyzing the relationship between stock and house prices. Portfolio theory suggests that a price increase in one asset affects optimal portfolio weights, since the value of this asset increases relative to other assets. To optimize the allocation of different asset types, households sell the asset which has increased in price and purchase other assets (Green 2002). According to this portfolio adjustment effect, an appreciation in stock prices thus increases the demand for housing, which has a positive effect on house prices. Similarly, a house price appreciation increases the demand for stocks. However, this does not automatically cause stock prices to rise, since stock prices are determined by future earnings and dividends (in accordance with standard stock valuation models e.g. Gordon's model) rather than the demand for the stocks themselves. Hence, portfolio theory predicts a positive causal relationship between stock and house prices, but unlike the wealth effect the portfolio theory only predicts a unidirectional causality from stock prices to house prices and not in the opposite direction.

Predictors of market returns

Both the wealth effect and the portfolio theory imply a positive causal relationship between the stock and housing markets as presented above. However, are there any other mechanisms that imply a negative relationship between the markets?

Empirical investigations on patters of returns suggest that there is a *positive* serial correlation over short horizons, implying that positive (negative) return tend to follow positive (negative returns). This is a momentum type of property and if trading strategies are based on this pattern, there will be a negative causal relationship from stock prices to house prices. Large investment inflows into one market lead to reduced investment in the other market. Since stock prices do not change, by change in the demand for stocks, only house prices should be affected. However, these studies only demonstrate a weak serial correlation over short horizons and no obvious trading opportunities exist. Hence, a negative causal relationship is not likely[6].

Related studies over long-run horizon returns have actually found a *negative* serial correlation in the performance of the aggregate stock market (Bodie, Kane et al. 2005). A Contrarian investment strategy (e.g. selling stocks if stock market has performed very well), if anything, strengthens the wealth effect and the portfolio theory. As explained above, only house prices will change according to this effect. Hence, also the empirical evidences suggest that there should be a positive relationship from stock to house prices.

3.3 Hypotheses

Hypothesis 1: There is a positive causal relationship between stock and house prices in Sweden.

We argue that there is a positive causal relationship between stock and house prices in Sweden as predicted by the wealth effect through the channel of increased household consumption as any of the asset prices increases. Since changes in asset prices are unanticipated and seen as permanent, households act on changes in wealth.

[6] The Jagadeesh and Titman (1993) findings of a momentum effect in which good or bad performance of individual stocks (as opposed to an aggregate stock market index) continues at short horizons, is not relevant in our study. We are concerned with the relationship between the stock market as a whole and the housing market.

Hypothesis 2: The direction of causality runs from the stock market to the housing market.

We hypothesize a one-way causal relationship from the stock market to the housing market based on the reasoning of the portfolio theory. The evidence of negative serial correlation of the aggregate stock market over longer horizon also suggests that the direction of causality should be positive and running from stock prices to house prices (in accordance with the Contrarian investment strategy). Moreover, since the stock market is random and unpredictable, the housing market should not have a significant impact on stock prices. The forward looking nature of the stock market also strengthens our view that the stock market would predict house prices rather than the other way around.

Hypothesis 3: Hypothesis 1 and 2 are also valid in Stockholm and the effect in Stockholm is stronger than in the rest of the country.

Due to a more inelastic supply of housing in Stockholm we argue that the causal relationship from stock prices to house prices is stronger in Stockholm than in Sweden. This reasoning is based on the investment theory of Tobin's Q. We also believe that the wealth effect is stronger in Stockholm than in Sweden because the households are wealthier and hold both more stocks and houses in Stockholm (See *Table 1A* and *1B).* The effect of a price change in stocks would hence affect the consumption behavior more in Stockholm than in Sweden leading to a larger impact on house prices in Stockholm. Moreover, the portfolio theory should be more prominent in Stockholm than in Sweden, since households in urban areas more commonly consider houses as an investment good compared to rural areas (Kapopoulos, Siokis 2005).

4 Methods

In this section, the methodology used in this study is presented. To examine whether there are any causal relationship between stocks and house prices we use a granger-causality test that builds on either a vector autoregressive model or a vector error correction model. The test for granger-causality is presented in section 4.1. In section 4.2 the underlying assumptions of the granger-test is presented and finally, in section 4.3 the method for conducting an in-depth analysis is used, i.e. the impulse-response test.

4.1 Testing for granger-causality

Various tests for causality have been developed in the recent decades; the most well known are the granger-causality test and Sims test of causality (Gujarati 2003). Since the granger-causality test is the most frequently used in previous literature in the area of study, we have chosen to apply this methodology. In this way our results become easier to compare with the results of other studies.

The granger-causality test is used to determine if the past value of one variable adds explanatory power when looking at the present value of another variable. The granger-causality test is based on the estimation of either the vector autoregressive model (henceforth labeled VAR) or, depending on the interrelationship between the variables included in the model, an extended version of the VAR model - the vector error correction model (henceforth labeled VEC). If the variables included in the model are cointegrated the VEC model has to be used. Cointegration implies that two series can individually be non-stationary, but a linear relationship between the two is stationary. Stationary implies that the mean and the variance of the time series included do not systematically vary over time, i.e. that they do not contain any unit roots. If the variables are not cointegrated the classical VAR model should be used instead.

The logic for the VAR and VEC models are fundamentally the same, building on simultaneous-equation modelling where several endogenous variables are included. Each endogenous variable is explained by its own past (or lagged) value as well as the past values of all other endogenous variables in the model (Gujarati 2003). In *Equation 1* below, a VAR model with two dependent variables is pictured. In the two simultaneous equations both X and Y can once be found on the left hand side in the equations, and they are both being explained by their own past values and by the past values of the other dependent variable. Unlike the classical regression model, the VAR model takes into account that the included variables can be correlated, since a change in one variable can have an impact on both equations in the model.

Equation 1

$$Y_t = \sum_{i=1}^{n} \alpha_{1,i} X_{t-i} + \sum_{i=1}^{n} \beta_{1,i} Y_{t-i} + u_{1,t}$$

$$X_t = \sum_{i=1}^{n} \alpha_{2,i} X_{t-i} + \sum_{i=1}^{n} \beta_{2,i} Y_{t-i} + u_{2,t}$$

X_t; Y_t:	*dependent variables at time t*
n:	*number of included lags*
$\alpha_{x,i}$; $\beta_{x,i}$:	*coefficients for row x, with lag-length = i (where i = 1, 2, 3,…, n)*
$u_{x,t}$:	*residual for row x, at time t*

The difference between the VAR and the VEC model is that the VEC model adds one or more error correction mechanisms (henceforth labeled ECM:s) to the equations in the model, to account for the cointegration relationships among the included variables. If there are any cointegrated relationships among the variables in the model, the VEC model will better capture the short run dynamics among the variables. One ECM should be added for each cointegrated relationship in the model. The error correction terms are calculated as the residuals from the cointegrating equations with a one period lag[7] (Ansari 2006).

Equation 1 is used in the most basic granger-causality test. The main focus of the test is to see whether the coefficients α_1 and/ or β_2 are significantly different from zero. If one of them (or both) is different from zero, causality in a granger sense is present, saying that the past value of one variable is significant for explaining the present value of the other variable.

Three different outcomes are possible in the granger-causality test:

- Unidirectional causality: implies that one variable causes another variable i.e. from X to Y or from Y to X. For example, unidirectional causality running from Y to X, would be present if any of the estimated coefficients for Y_{t-i} ($\beta_{2,1}$ or $\beta_{2,2}$ or …$\beta_{2,n}$) are

[7] For example, if X and Y are cointegrated, ECM is equal to u_t in the simple equation: $y_t=kx_t+u_t$

statistically different from zero at the same time as all the estimated coefficients for X_{t-i} ($\alpha_{1,1}$ or $\alpha_{1,2}$ or …$\alpha_{1,n}$) are not significantly different from zero.

- Bidirectional causality: implies a causal relationship in both directions, from X to Y and from Y to X.
- Independence: implies no causality. Then, none of the coefficients for X and Y (α_i and β_i) would be significantly different from zero.

The null hypothesis in the granger-causality test is that α_i and/or β_i (the coefficients for the lagged explanatory variables) are zero, and hence that there are no causal relationship in the model.

The null hypothesis when testing for causality from X to Y:

H_0: $\alpha_{1,i} = 0$ (indicating *no* causal relationship)
H_1: $\alpha_{1,i} \neq 0$ (indicating a causal relationship)

Criteria for the granger-causality test and important assumptions

One of the basic assumptions in the granger-causality test is that the variables have to be stationary. Time series in levels are often non-stationary, thus to create stationary time series that can be used in the granger-causality test, the first differences of the time series are commonly used.

Another important part of the granger-causality test is that the number of lags in the model can be of vital importance for the direction of causality. When determining the maximum lag length, one has to consider that too many lagged terms will reduce the degrees of freedom in the model, leading to a lower explanatory power. Including too few lags could on the other hand lead to specification errors. A statistically accepted way of determining the appropriate number of lags for the granger-causality test is the Akaike information criterion (Gujarati 2003).

Furthermore, it is important to consider which control variables to add in the test. If the granger-causality test is conducted without any control variables two variables can appear to have a causal relationship even if they do not, since there may in fact be a third variable that affects them both and generates their relationship. This would lead to spurious results of the model. For example, if we run *Equation 1* above with X and Y, it may be the case that there is a hidden variable, Z, that affects both X and Y. Since Z is not included in the model it will appear as if X and Y cause each other even if they do not. When adding the control variable, in this case Z, this problem will be solved. When no control variable is included, the granger-causality test cannot with certainty determine a causal relationship between the variables (Granger 1980). Hence, the important thing to take into account when choosing control variables is that they should be likely to affect both X and Y.

Moreover, another underlying assumption in the granger-causality test is that the data does not include structural breaks. A structural break appears when we see an unexpected shift in a time series which creates a new parameter regime. If a structural break would be included in the data, this could lead to significant forecasting errors and unreliability of the model in general (Juselius 2008, Okunev, Wilson et al. 2002).

Finally, in the granger-causality test one should also thoroughly consider what kind of time series data to use in the model. For example problems might occur if the causality appears on a weekly basis but the data used is monthly (Granger 1980).

4.2 The impulse-response function

When conducting a granger-causality test, an impulse-response function is useful for estimating the size of impact that a change in one variable may have on the other variable in a VAR or a VEC model. The impulse-response function outlines the response of the dependent variable to shocks in the error terms (such as u_{1t}.and u_{2t} in *Equation 1*). The shock (i.e. a onetime impulse) is inserted to investigate more in detail how the other variable will react in order to generate a more profound picture of the causal relationship. A onetime impulse in one variable can have a permanent effect on the other variable and therefore not die out to zero but instead approach a non-zero value (Lütkepohl 2007). If no granger-causality is present, the response in one variable from an impulse in the other variable will be zero.

5 Data

In this section, the data used in the study is presented. In section 5.1 the choice of time period is reported. In the following section 5.2, the data for the main variables are described and in section 5.3 the choice of control variables are reported.

5.1 The time period

The time period 1992q1-2009q1 is chosen since it fulfils the assumption of the granger-causality test of not including a structural break in data. According to Berg and Berger (2006) a structural shift in the housing market took place around 1992. The Swedish financial market went through some major regulatory changes in the 1980s. A liberalization of the financial market enabled the private sector to become more leveraged which lead to price increases in both the stock market and the real estate market (Englund 1999). Parallel to the financial deregulation, other changes took place that affected the housing market significantly; the real interest rate increased as monetary policy shifted to focus more on keeping inflation low and stable, the interest rate subsidy for new house owners was reduced and a new tax reform took place (Berg, Berger 2006, Englund 1999). The combined effects of changes in tax rules and housing policies at the end of the 1980s and in the beginning of the 1990s were fully felt in 1992 (Berg and Berger 2006). Berg and Berger (2006) reach the conclusion that these major changes in the financial environment in Sweden caused a structural shift in the housing market and lead to a more market driven house prices after 1992. In order to ensure that our data not will include information from periods with different structural presumptions we have chosen to limit our data to start the first quarter in 1992.

5.2 Main variables - stock prices and house prices

To represent house prices, we use the real estate price index from Statistic Sweden, for Sweden and for Stockholm county. This index describes the price development in the regions for one and two family dwellings for permanent use. Quarterly data is used and we believe that this is suitable to capture the causal effects between house and stock prices since house prices move quite slowly. The index estimates the changes in prices and values of all one and two family dwellings. The real estate price index also takes into account that houses sold might not be a random sample and that different compositions of houses sold may vary between years. Information for all one and two family dwellings and all sold properties are included in the index. Therefore, the index only reflects changes in prices and not quantity; hence, it is a preferable index to use when measuring house prices in Sweden.

To represent stock market prices, we use the OMXS, the price index of all stocks registered at the Nasdaq OMX Stockholm stock exchange. Quarterly data on the development of OMXS was attained via Thomson Datastream (Datastream Advance Version 4.0 SP7), the world's largest financial statistical database.

5.3 Control variables – interest rate and GDP

As previously discussed, the result of the granger-causality test may become spurious if a third variable that affects both stock and house prices is not controlled for in the model (previously described as Z in section 4.1). Then it may seem as stock and houses have a causal relationship while in fact it is the third variable that generates their relationship. Hence, in order to avoid a spurious regression, common explanatory variables for stock and house prices must be included in the model.

Several previous studies have empirically examined the common explanatory variables for both stock and house prices. Numerous studies have concluded the interest rate should be an important determinant of stock and house prices. Several studies have also concluded that the short run interest rate is in particular a common factor that affects the two markets (Ong 1994, Yang 2005, Liu, Mei 1998, Ling, Naranjo 1999). The monthly payments for leveraged house owners are affected by the interest rate on mortgages, which has an influence on the demand for houses and thereby house prices (Beenstock, Chan 1988, Chen, Roll et al. 1986, Gallagher, Taylor 2002). For the stock market, the interest rate is a determinant of the return requirement. If the interest rate increases, stock market prices decrease in accordance with standard stock valuation models (e.g. Gordon's model). Moreover, much emphasis in previous literature has been given to the development of the economic activity for explaining stock and house prices. Variables such as the growth rate in the real per capita consumption (Ling, Naranjo 1999), economic growth, current and expected earnings and growth in industrial production have been suggested as important common drivers for the development in the two markets (Ling and Naranjo 1999, Ong 1994). The intuition behind the relationship between economic growth and the development of house prices is that households' income (that is positively connected to economic growth) would affect their willingness to pay for housing and thereby affect the house prices. For stock market prices, economic growth affects expected earnings and dividends and consequently stock market prices.

Against this background, we have chosen to include the nominal gross domestic product (GDP) and the short run, risk free interest rate as control variables in our model. Moreover, several previous studies examining the causal relationship between stock and house prices have also used GDP and the interest rate as control variables (further described in section 6). By using the same control variables as previous studies it becomes easier to compare our results in relation to other studies.

To represent income we use quarterly data on Swedish nominal GDP from Statistics Sweden and to represent the interest rate we use quarterly data on the three-month Swedish treasury-bill published by the Swedish central bank. There are also other variables that could be important for explaining both stock and house prices. However, we believe that the two variables chosen will be sufficient to reduce the main influences from external variables. A further discussion of this follows in section 7.3.

6 Results

In this section the results are presented. In section 6.1 pre-testing of the data are reported, including testing for stationarity and cointegration to assure that our model fulfils the underlying assumptions of the granger-causality test. Section 6.2 presents the results of the granger-causality tests and section 6.3 shows the results of the in-depth analysis where the impulse-response function is constructed. Throughout this section we present our results together with previous findings.

6.1 Pre-testing the data

The first stage when testing for granger-causality is to examine the order of integration in the data, i.e. to test for stationarity. To fulfill the assumptions behind the granger-causality test the variables need to be stationary. To see if the variables are stationary we perform the augmented Dickey-Fuller test on the data with the variables logged in levels. The results are presented in *Table 2*. For all variables we find that the null hypothesis of non-stationarity is not rejected at the ten percent level (p>0.10). Hence, the variables are in themselves non-stationary. To avoid a spurious regression we therefore use the time series data in first differences instead of levels, since the variables in first differences are stationary.

Table 2: The Dickey-Fuller test of stationarity

Logged variables	Test statistic	MacKinnon p-value
Stock prices	-1.899	0.333
House prices Sweden	1.432	0.997
House prices Stockholm	0.677	0.989
3 month t-bill	-0.621	0.866
GDP	-1.348	0.607

For all variables the test statistic > 10% critical value -2,539
The null hypothesis of no stationarity is rejected at MacKinnon's p-value<0.1

Since the augmented Dickey-Fuller test shows that the included variables are non-stationary in levels, it is possible that a linear relationship between them is stationary, i.e. that they are cointegrated. To test for cointegration, we use Johansen's multivariate test (see *Table 3*), which is one of the most widely used. The star in *Table 3* points out the row that corresponds to a rank number that indicates how many cointegration relationships our model contains.

Johansen's multivariate test shows that there is one cointegration relationship among the variables in our model, both for Sweden and Stockholm. This implies that we have to use a vector error correction model (VEC) instead of the basic VAR model and hence include an error correction mechanism in the granger-causality tests, to account for the interrelationships between the variables.

Table 3: The Johansen test for cointegration

Rank	Critical value	Trace statistics Sweden	Trace statistics Stockholm
0	47,21	54,90	61,85
1	**29,68**	**23.59***	**29.21***
2	15,41	5,64	14,04
3	3,76	0,06	0,37

** Indicates the significant rank (i.e. the no of cointegration relationships); The test is conducted at a 5% significance level*

6.2 The granger-causality test

As a result of the tests for stationarity the variables in the model are converted to first differences, i.e. the quarterly percentage changes. Since we identified one cointegration relationship among the variables, the granger-causality test is conducted using the VEC model estimated below (see *Equation 2*). The VEC model includes one error-correction mechanism (ECM), which corresponds to the cointegration relationship identified in the Johansen test.

Equation 2

$$\Delta S_t = \sum_{i=1}^{n} \alpha_{1,i}\, \Delta \mathrm{S}_{\mathrm{t}-i} + \sum_{i=1}^{n} \beta_{1,i} \Delta H_{t-i} + \sum_{i=1}^{n} \gamma_{1,i}\, \Delta \mathrm{r}_{t-i} + \sum_{i=1}^{n} \delta_{1,i}\, \Delta \mathrm{GDP}_{\mathrm{t}-i} + \theta_1 \mathrm{ECM}_{t-1} + \mathrm{u}_{1,\mathrm{t}}$$

$$\Delta H_t = \sum_{i=1}^{n} \alpha_{2,i} \Delta\, \mathrm{S}_{t-i} + \sum_{i=1}^{n} \beta_{2,i} \Delta H_{t-i} + \sum_{i=1}^{n} \gamma_{2,i} \Delta\, \mathrm{r}_{t-i} + \sum_{i=1}^{n} \delta_{2,i}\, \Delta \mathrm{GDP}_{\mathrm{t}-i} + \theta_2 \mathrm{ECM}_{t-1} + \mathrm{u}_{2,\mathrm{t}}$$

$$\Delta r_t = \sum_{i=1}^{n} \alpha_{3,i}\, \Delta \mathrm{S}_{\mathrm{t}-i} + \sum_{i=1}^{n} \beta_{3,i} \Delta H_{t-i} + \sum_{i=1}^{n} \gamma_{3,i}\, \Delta \mathrm{r}_{\mathrm{t}-i} + \sum_{i=1}^{n} \delta_{3,i}\, \Delta \mathrm{GDP}_{\mathrm{t}-i} + \theta_3 \mathrm{ECM}_{\mathrm{t}-1} + \mathrm{u}_{3,\mathrm{t}}$$

$$\Delta GDP_t = \sum_{i=1}^{n} \alpha_{4,i}\, \Delta \mathrm{S}_{\mathrm{t}-i} + \sum_{i=1}^{n} \beta_{4,i} \Delta H_{t-i} + \sum_{i=1}^{n} \gamma_{4,i}\, \Delta \mathrm{r}_{\mathrm{t}-i} + \sum_{i=1}^{n} \delta_{4,i}\, \Delta \mathrm{GDP}_{\mathrm{t}-i} + \theta_4 \mathrm{ECM}_{\mathrm{t}-1} + \mathrm{u}_{4,\mathrm{t}}$$

ΔS_t:	*First difference of the logged stock price index OMXS at time t.*
ΔH_t:	*First difference of the logged house price index at time t.*
Δr_t:	*First difference of the logged real interest rate at time t.*
ΔGDP_t:	*First difference of the logged GDP at time t.*
ECM_{t-1}:	*Error correction term at time t-1.*
$\alpha_{x,i}$; $\beta_{x,i}$; $\gamma_{x,i}$: $\delta_{x,i}$: $\theta_{x,i}$:	*Coefficients for row x, with a time lag i (i=1,2,…,n).*
n:	*Number of lags included.*

The optimal lag lengths were five quarters for both Sweden and Stockholm determined by Akaike's information criteria. The number of five lags also meets the criteria of maintaining sufficient degrees of freedom in our test.

As demonstrated in *Equation 2*, all the included variables in the model appear once on the left hand side in the system of equations. Moreover, they all depend on their own lagged value, the lagged value of the other included variables and the error correction term. The coefficients of interest for the granger-causality test between stock prices and house prices are $\alpha_{2,i}$ and $\beta_{1,i}$. $\alpha_{2,i}$ measures the impact of the lagged stock prices on house prices when controlling for the GDP and the interest rate. Similarly, $\beta_{1,i}$ measures the impact of lagged house prices on stock prices. The signs of the coefficients ($\alpha_{2,i}$ and $\beta_{1,i}$) determine whether the causal impact is positive or negative. The results for granger-causality are presented in *Table 4* and 5 for Sweden and Stockholm respectively (further details of the test can be found in Appendix 1).

Table 4: The granger-causality test, Sweden

Sweden	Lag	Coefficient	p-value	n
Stock prices cause house prices	**1**	**0.036**	**0.016***	64
	2	**0.032**	**0.037***	64
	3	0.009	0.566	64
	4	0.014	0.361	64
House prices cause stock prices	1	-2.169	0.127	64
	2	-0.329	0.825	64
	3	-0.858	0.589	64
	4	1.721	0.255	64

** Significant at a 10% level*

In Sweden, the null hypothesis of no granger-causality from stock prices to house prices is rejected since the coefficient α_2 is significantly different from zero ($p<0.1$). However, the null hypothesis of no granger-causality from house prices to stock prices is not rejected since the coefficient β_1 is not significantly different from zero. This implies unidirectional causality from stock prices to house prices in Sweden. Moreover, the significant coefficients for lagged stock prices ($\alpha_{2,i}$) are positive which implies a positive relationship between the variables.

In Stockholm, the null hypothesis of no granger-causality from stock prices to house prices is also rejected (see *Table 5*); the coefficient for stock prices, α_2, is found to be significantly different from zero ($p<0.1$). Similar to the Swedish results, the null hypothesis of no granger-causality from house prices to stock prices is not rejected since β_1 was not significantly different from zero. This implies a unidirectional causality relation between the markets in Stockholm, running from stock prices to house prices. Also here the coefficient for the lagged stock variable ($\alpha_{2,i}$) is positive implying a positive relationship between the price series.

Table 5: The granger-causality test, Stockholm

Stockholm	Lag	Coefficient	p-value	n
Stock prices cause house prices	1	0.026	0.270	64
	2	**0.041**	**0.093***	64
	3	0.003	0.881	64
	4	0.030	0.158	64
House prices cause stock prices	1	-0.578	0.585	64
	2	-1.354	0.200	64
	3	0.564	0.584	64
	4	1.527	0.134	64

** Significant at a 10% level*

The results for Sweden are similar to previous findings on granger-causality between the stock and housing markets. A study from the Bank for International Settlements (2003) looks at equity-market peaks from the 1970s until the late 1980s in six countries: Canada, Japan, Sweden, the United States, the United Kingdom and Australia. Overall, it finds that peaks in stock prices tend to be followed by peaks in house prices. Additionally, a more comprehensive study by Sutton (2002) also identifies a positive causal relationship running from the stock market to the housing market. Sutton examines to what extent house prices can be explained by stock prices, interest rates (both short and long run interest rates) and national income, by looking at quarterly data for the period 1973-2002 in six countries: the United States, Canada, the United Kingdom, Ireland, the Netherlands and Australia. Similar to the result in the present thesis, he finds that there is a positive relationship between changes in stock prices and house prices for all countries included in the study. The methodology Sutton uses is quite similar to our approach; he performs a granger-causality test with the national income and the interest rate as control variables.

The results from the granger-causality test in Stockholm are also in line with earlier findings. A number of previous studies have examined whether urban and wealthier areas have different characteristics regarding the relationship between stock and house prices compared to the country as a whole. As mentioned in section 1.2, Berg and Lyhagen (1998) look at the determinants of house prices in different areas in Sweden between 1981 and 1997. They conduct a granger-causality test based on the VAR structure without including control variables. In accordance with our results, Berg and Lyhagen also find a positive unidirectional causal relationship from stock to house prices in Stockholm. However, in contrast with our study, Berg and Lyhagen do not find any causal relationship between stock and house prices in Sweden as a whole.

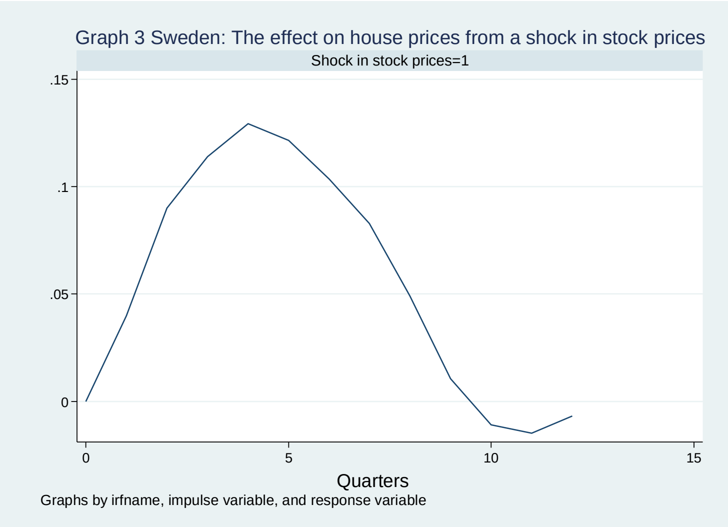
A study based on data from Korea identifies the opposite causal direction, running from the housing market to the stock market (Sim, Chang 2006). By testing for granger-causality and controlling for the GDP and the long-term (three year) interest rate, they find a unidirectional causal relationship running from the house and land market to the stock market. The differences between our results will be discussed further in section 7.1.

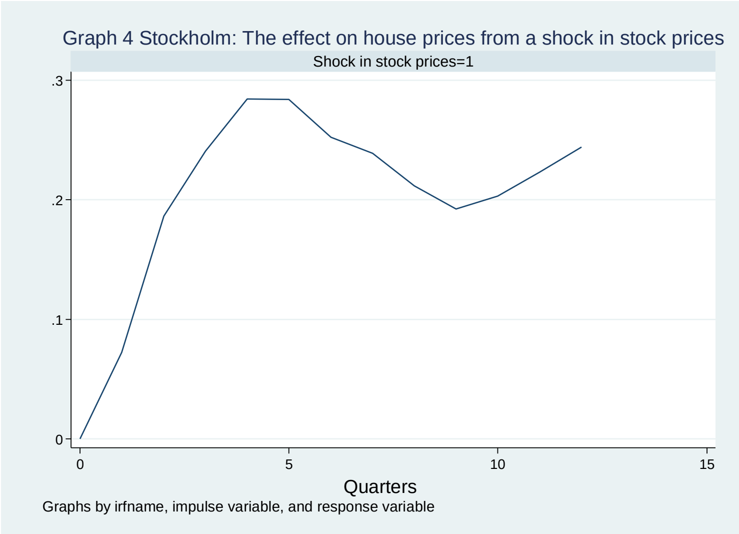
To conclude, the results from the granger-causality test indicate that there is a positive unidirectional causal relationship from stock prices to house prices in both Sweden and in the Stockholm area. These results are quite consistent with findings in previous studies on this topic. A further discussion of these results and the similarities and differences between our findings and other studies will follow in section 7.1.

In-depth analysis: the impulse-response function

After performing a granger-causality test, an impulse-response function is created to investigate what impact a shock in stock prices has on house prices over three years (or 12 quarters), controlling for GDP and the interest rate. The impulse-response model is built on the system of equations presented in *Equation 2* above, where a shock in stock prices (an impulse) is inserted through the error term on the second row of the equation for house prices ($u_{2,t}$).

Two impulse-response functions are created to analyze the causal realtionship that runs from stock prices to house prices, one for Sweden and one for Stockholm. *Graph 3* and *Graph 4* picture how house prices in Sweden and in Stockholm reacts on a shock in stock prices at t=0. The shock in the graphs correspond to a positive change of one unit in stock prices, and the y-axis shows the effect this has on house prices (e.g. 0.10 is interpreted as a one percent increase in house prices if stock prices increases by ten percent). For both Sweden and Stockholm, the estimated models forecast that a shock in stock prices yields a positive response in house prices as predicted by the granger-test in the previous section. Point estimates (see Appendix 2) indicate that a ten percent increase in stock market prices in Sweden causes an 1.3 percent increase in house prices over one year, after this the effect turns and fades out to zero. In Stockholm, the impulse-response function shows that a similar shock in stock prices causes a house price appreciation by 2.8 percent after the first year and the effect during the subsequent periods continues to be positive and never dies out. Hence, the impact on house prices from a shock in stock prices is both larger (1.3 percent versus 2.8 percent) and more persistent in Stockholm compared to Sweden. The time lag, from the time when the shock in stock prices is inserted until it has a full impact on house prices is one year (four quarters) for both Stockholm and Sweden.





Several international studies have compared the causal relationship between stock prices and house prices between different geographical areas with a similar result. Kakes and Van (2004) compares the causal relationship between different price segments in the Dutch housing market. He uses a granger-causality test where he controls for the interest rate and disposable income. Similar to us, they find a unidirectional causality running from the stock market to the housing market in the Netherlands, with an even stronger unidirectional causal relationship in the most expensive segment of the housing market. Kakes and Van also use an impulse-response test, and finds that an impulse in equity prices of 10.0 percent causes a response of approximately 1.4 percent for houses in the most expensive segment after one year and 4.9 percent after three years. Hence, the effect from stock to house prices in the most expensive area in the Netherlands is similar to the results in Sweden after one year but the effect in the Netherlands is increasing over time and similar to the results in Stockholm it is shown to be persistent.

Furthermore, Green (2002) looks at different price segments of houses in California. He uses the granger-causality test without adding any control variables. Similar to us, he finds a stronger relationship between stock and house prices in the wealthier area. A 10.0 percent increase in stock prices, increase house prices in the wealthier area by 8.8 percent and in the less wealthy area house prices increase by 2.2 percent. In both areas the effect dies out almost entirely after one year.

A study by Kapopoulus and Siokis (2005) compares Athens to other urban areas in Greece by applying a granger-causality test without control variables. They find that stock prices granger-cause real estate prices in Athens but not in other urban areas[8]. Kapopoulus and Siokis do not perform an impulse-response test and do not determine the size of the differences in impact between rural and urban areas.

In this study we identify a time lag of one year before the effect from a change in stock prices has full impact on house prices. Sutton (2002) identifies different lag lengths with varying magnitudes of impact among the countries included in his study (the United States, Canada, the United Kingdom, Ireland, the Netherlands and Australia). He finds that a 10.0 percent increase in stock prices typically yields 0.3 percent rise in house prices in the United States, 0.9 percent in Canada and 1.0 percent in Ireland over one year. In the United Kingdom, the Netherlands and Australia a 10.0 percent increase in stock prices generates a house price appreciation by 1.5, 0.2 and 0.7 percent respectively after one year. This can be compared to the house price appreciation of 1.3 percent in Sweden and 2.8 percent in Stockholm after a one-year period found in our study. The housing market in Sweden shows one of the largest reactions to stock price changes among the countries compared (only the United Kingdom has

[8] Real estate includes houses, land and commercial buildings.

a larger increase in house prices during the first year). On the other hand, the Swedish reaction to a shock in stock prices dies out to zero after nine to ten quarters while the reactions for the countries in Sutton's study are persistent over twelve quarters. In the United Kingdom the effect even increases to around 5 percent after 36 quarters (three years) and the Netherlands and Australia show a 2.3 percent and 2.0 percent reaction respectively. For Stockholm, the impulse-response function is more in line with previous findings for other countries as the impact from stock prices to house prices is shown to be a more persistent effect.

To conclude, the in-depth analysis shows that the causal relationship from the stock market to the housing market has full impact after a lag of four quarters (or one year). A change in stock prices in Sweden results in a sharper, but less prolonged impact on house prices than in other countries, whereas the findings from other countries shows that the impact generally is less in the short run but that the duration is longer. Moreover, our findings show that the causal relationship is stronger and more persistent in Stockholm than in Sweden. The stronger relationship in Stockholm is in accordance with previous studies that examine other wealthy and metropolitan areas. These results and their implications will be discussed further in the following section 7.1.

7 Discussion

This section, discusses the results presented above. First, in section 7.1 we interpret the results in relation to our hypothesis and discuss the differences between our results and previous findings. In section 7.2 we present the practical implications of our findings and in section 7.3 we discuss possible areas of improvement for future research.

7.1 Results in relation to previous findings and theoretical implications

The results in this thesis are in line with our original hypotheses; we identify a positive causal relationship between stock and house prices, both in Sweden and in Stockholm. Moreover we find that this relationship runs from the stock market to the house market and that this relationship is stronger in Stockholm than in Sweden as a whole.

The causal relationship

Several theoretical perspectives predict the existence of a causal relationship between stock and house prices and that this relationship should be positive. We interpret our findings as a result of the wealth effect, which implies that households wish to consume more housing if their wealth increases through increasing stock prices, which leads to increasing house prices. Furthermore, we argue that households sell stocks when they increase in value and invest more in houses in order to optimize the allocation of assets in their portfolios according to portfolio theory. This is also in line with the Contrarian investment strategy. The increased demand for houses has a positive effect on house prices which entails a positive relationship from stocks to houses as found in our statistical analyses.

Similar to our results, most previous studies find a positive causal relationship from the stock market to the housing market. However, our result differs from the Swedish study by Berg and Lyhagen (1998) which concludes that stock prices granger-causes house prices in Stockholm but not in Sweden as a whole. The explanation for this is most likely that Berg and Lyhagen use another measure for housing and stock prices[9] and that they look at the period 1981-97, a time period with very different characteristics than 1992-2009. Furthermore, in their analysis on stock and house prices they perform a bivariate study without control variables, which may lead to spurious results as described in section 4.1.

[9] Berg (1998) used the purchase price coefficient that is better suited for analyzing data in levels than in differences see discussion about our choice in section 5.2 and 7.1. Furthermore, he looks at the AXFG index instead of OMXS.

In comparison with results from other countries - the United States, Canada, Ireland, the Netherlands and Australia (Sutton 2002) - Sweden shows one of the largest causal effects from stock to house prices. Only in the United Kingdom the causal effect is greater. We interpret this as a result of a larger impact of the wealth effect and the portfolio adjustment effect in Sweden, similar to the one that can be observed in the UK. A larger wealth effect implies that households' are more likely to react on changes in stock prices and therefore consume more including that of housing, leading to higher house prices compared to other countries. In the United States, the impact from stock prices to house prices was the smallest among the countries compared even though both stocks and houses are broadly held. An explanation for this can be that households in the United States do not regard their stock market gains as permanent compared to other countries as predicted by the permanent income hypothesis (Sutton 2002). A presence of the Momentum investment strategy in the United States could also offer an explanation for this since it implies a negative relationship between the assets that would reduce the impact of the wealth effect.

As previous mentioned a study based on data from South Korea identifies the opposite causal relationship compared to our results (Sim, Chang 2006). Hence, they identify a causal relationship running from the housing market to the stock market. South Korea differs from Sweden in several ways; for one thing, the share of households that hold stocks is small compared to Sweden and households also invests more heavily in real estate (Sim, Chang 2006). Since they have such a large proportion of real estate compared to stocks, it is reasonable that the wealth effect runs from the housing market to the stock market.

Stockholm versus Sweden as a whole

Similar to previous literature that looks at the relationship between the stock market and different segments of the house market, we find a stronger causal relationship from stock to house prices in Stockholm than in Sweden. A 10.0 percent increase in stock prices resulted in an appreciation of house prices in Stockholm and Sweden by 2.8 and 1.3 percent respectively. We interpret the stronger effect in Stockholm as a result of inelastic housing supply in the region. According to Tobin's Q, the change in the rate of construction caused by a shift in demand should thereby be smaller in Stockholm than in Sweden. This implies that changes in demand (e.g. caused by changes in stock prices) will have a greater impact on house prices in Stockholm than in Sweden.

The greater effect in Stockholm is also likely to be a result of higher household wealth (of both stocks and houses) in average in the Stockholm area compared to the rest of the country, as predicted by the wealth effect. The greater wealth implies that the assets are more likely to be affected by each other, and hence have a stronger causal relationship. Additionally the portfolio adjustment effect is likely to have larger impact in Stockholm compared to Sweden due to the fact that households' in Stockholm to a larger extent are likely to consider houses as an investment good. A more dominant portfolio theory strengthens the wealth effect, leading to a stronger relationship between the assets.

We also found differences between Sweden and Stockholm regarding the persistence of the impact from stock to house prices over time. In Stockholm the causal effect is shown to be persistent but in Sweden the causal impact from stock prices to house prices dies out after about nine quarters. An explanation for this can be supplied by the theory of Tobin's Q. A shock in the demand for housing (e.g. caused by increasing stock prices) would increase the rate of construction in both rural and urban areas. Houses are not constructed over night; hence the supply of houses will in the short run be inelastic in both rural and urban areas, pushing house prices upwards. However, as soon as new houses have been built (presumably after about one year) the supply of houses in rural areas will become more elastic, and the positive effect on house prices will diminish. In urban areas on the other hand, where housing supply generally is more inelastic the effect on house prices will remain high.

Comparing our results to the study by Kakes and Van (2004), we find that the impact from stock to house prices is smaller in the richer segment of the Dutch housing market than in Stockholm, 1.4 and 2.8 percent respectively after an increase in stock prices of 10.0 percent. On the other hand our results are significantly smaller compared to the results from California where Green (2002) finds an impact from stock to house prices in the wealthier area of 8.8 percent after a 10 percent increase in stock prices. Our differences can be explained by the fact that we use a different approach, since this study looks at Stockholm as a whole instead of a certain segment of houses in the house market. Moreover, the average house in wealthy areas in California are more expensive than in Stockholm and households there commonly hold more stocks than in the Stockholm area.

7.2 Practical implications

The causal relationship from the stock market to the housing market has practical implications for both households and policy makers since these assets constitute a large part of households' wealth. The positive causal impact from the stock market to the housing market implies that changes in stock market prices affect house prices in the same direction and hence reinforce the effects on households' wealth. If stock prices for example fall by 10.0 percent, our findings indicate that house prices would fall by 1.3 percent after one year. This implies that the households' total wealth would fall with approximately 135 billion SEK (42 billion in housing and 93 billion in stocks, see *Table 1*). Fluctuations like this could have a large impact on households' consumption, and thereby on the Swedish economy as a whole. Also very small changes in house prices could have a huge impact on consumption since increased house prices make it possible to borrow more. Our findings strengthen the view that there is a need for households to hedge against falling house prices. A tool for hedging against house price fluctuations would obviously be useful, since we found that the asset prices move in the same direction.

Moreover, house prices have contributed to financial crises over recent decades and have thereby affected financial stability. Our results are important for policy makers since we show that stock prices can work as a leading indicator for the development of house prices**.** With this information banks can improve their lending policy towards households and in that way avoid severe credit risks. If stock prices are falling, we can also expect house prices to fall after one year and hence, the banks should apply a more restrictive lending policy.

Our results should also be useful in the area of monetary policy. To reach the inflation target of two percent the central bank must foresee the development of asset prices and set the repo rate path accordingly. Our results can be an additional tool for estimating the development of asset prices.

7.3 Areas of improvement and ideas on future studies

It would have been interesting to compare the Swedish data to a wealthier area in Sweden instead of Stockholm county as a whole. This would probably have led to more striking differences between the regions since the level of household wealth has been shown to determine the impact of the causality relationship. Initially we tried to obtain data on house prices from the Danderyd district, the wealthiest area in Sweden, but unfortunately only annual data is available and this would have given us too few observations to study. We also tried to attain data on the Swedish house prices with the Stockholm county excluded to remove the effect that the Stockholm region would have on Swedish data and thereby increase the possible differences we hoped to find between the regions. Unfortunately, also here only annual data is available. Finally, we also tried to obtain data for flats and multi-family dwellings, to include in our study. We believe that this could have given especially interesting results in the Stockholm region since many people in the region lives in, and owns flats. However, the collection of this data only began in 2003 and since our analysis started in 1992, we could not include it in our study.

Another interesting topic for future studies would be to only look at upturns and/or downturns in historical data when investigating the causal relationship. In this thesis we chose to limit our scope to cover the general behavior of time series data over the past 17 years since there were not enough peaks and troughs in this time period. Problems could have occurred by including upturns and downturns from both before and after 1993 due to the different characteristics of the stock and house market between these periods. Still, looking ahead this could be an interesting area to analyze in a few years from now, when all effects of today's financial crisis can be included in such a study as well.

One weakness in the causality test is that the lag lengths of five quarters for Sweden and Stockholm were limited by the size of our data. The number of observations (n=68) made it only possible to check for a maximum of five lags in order to maintain sufficient degrees of freedom. To solve this problem one option would have been to expand our data set and include more years but then we would have included the structural break in the early 1990s which could have caused spurious results (Juselius 2008, Okunev, Wilson et al. 2002).

It is worth noting that the house price development is rather stable during the time period studied. This may have affected our results, and our model may hence not be applicable on a time period with different characteristics. Another limitation in this thesis is that we only include the GDP and the interest rate as control variables. It could for example have been interesting to include a variable for expected house prices since that could have an effect on both house prices and stock prices. Other variables that could have been included are the expected income and unexpected inflation. However, since these variables are not easily estimated we decided to settle with the GDP and the short run interest rate to keep the thesis in a reasonable size and to make our results more comparable to previous studies. Still, it could be interesting to include these variables in a potential follow-up study.

8 Conclusion

This thesis investigates the relationship between house prices and stock market prices in Sweden and in Stockholm between 1992 and 2009. The results identify a positive causal relationship between the markets running from the stock market to the housing market in both Stockholm county and in Sweden as a whole. Moreover, the causal effect from the stock market to the housing market is shown to be stronger and more persistent in Stockholm. A 10.0 percent increase in stock prices yields increases in house prices in Stockholm and Sweden by 2.8 percent and 1.3 percent respectively after one year. In Stockholm the effect during subsequent periods continues to be positive and never fades out. However, in Sweden the effect turns after one year and fades out to zero after approximately two years.

By providing these results we wish to increase the understanding for how the stock and the housing market interact. These results are important for policy makers concerned with the households' financial situation, since the households' balance sheets are affected by changes in both stock and house prices. Especially the households in Stockholm should have a reason to consider our findings since stock prices have a greater impact on house prices in this area.

Moreover, our results should be of interest for policy makers concerned with financial stability since a positive connection between the markets could enhance both upturns and downturns in society. Our results can also be used for monetary policy purposes. When planning the repo rate path to maintain a low and stable inflation, central bankers have to predict the development of house prices. Our findings can be used as a complement when modeling this development.

Overall our results encourage a more cautious attitude towards the households' financial position since stock and house prices are shown to move in the same direction. Hereby this thesis also stresses the importance of creating a tool for households to hedge against house price fluctuations. This is especially relevant in times like this, when society faces financial distress.

References

ANDO, A. and MODIGLIANI, F., 1963. The "Life Cycle" Hypothesis of Saving: Aggregate Implication and Tests. *The American Economic Review,* **53**(1), 55-84.

ANSARI, M.I., 2006. The US Housing Boom and the Stock Market Decline: Searching for a Causal Nexus. *Finance India,* **20**(2), 513-530.

BANK FOR INTERNATIONAL SETTLEMENTS, 2003.
73rd Annual Report. *1 April 2002–31 March 2003,* 73rd Annual Report, 116-117-120.

BARNEKOW, E., 2002. *Demografi och finansmarknad - en översikt av empirisk forskning.* Sweden: Institutet för Framtidsstudier.

BEENSTOCK, M. and CHAN, K., 1988. Economic Forces in the London Stock Market. *Oxford Bulletin of Economics and Statistics,* **50**(1), 27-39.

BERG, L. and LYHAGEN, J., 1998. The Dynamics in Swedish House Prices - An Empirical Time Series Analysis. Working paper no 12 edn. Uppsala: Institute for housing research, Uppsala University.

BERG, L., 2002. Prices on the Second-Hand Market for Swedish Family Houses: Correlation, Causation and Determinants. *European Journal of Housing Policy,* **2**(1), 1-24.

BERG, L. and BERGER, T., 2006. The Q Theory and the Swedish Housing Market--An Empirical Test. *Journal of Real Estate Finance and Economics,* **33**(4), 329-344.

BLANCHARD, O.J. and QUAH, D., 1989. The dynamic effects of aggregate demand and supply disturbances. *American Economic Review,* **79**(4), 655-673.

BODIE, Z., KANE, A. and MARCUS, A., J., eds, 2005. *Investments.* Sixth Edition edn. Singapore: The Mc Graw Hill Companies.

CHEN, N.K., 2001. Asset price fluctuations in Taiwan:
evidence from stock and real estate prices 1973 to 1992. *Journal of Asian Economics,* **12**, 215-232.

CHEN, N., ROLL, R. and ROSS, S.A., 1986. Economic Forces and the Stock Market. *Journal of Business,* **59**(3), 383-403.

DATASTREAM ADVANCE, Version 4.0 SP7. Thomson Datastream, Thomson Financial Limited. Supplied by the Stockholm School of Economics.

DUSANSKY, R. and KOC, C., 2007. The Capital Gains Effect in the Demand for Housing. *Journal of Urban Economics,* **61**(2), 287-298.

ENGLUND, P., 2009. Indexderivat som skydd mot bostadsprisrisker. *Ekonomisk Debatt,* **4**, 22.

ENGLUND, P., 1999. The Swedish Banking Crisis: Roots and Consequences. *Oxford Review of Economic Policy,* **15**(3), 80-97.

GALLAGHER, L.A. and TAYLOR, M.P., 2002. Permanent and Temporary Components of Stock Prices: Evidence from Assessing Macroeconomic Shocks. *Southern Economic Journal,* **69**(2), 345-362.

GRANGER, C.W.J., 1980. Testing for causality : A personal viewpoint. *Journal of Economic Dynamics and Control,* **2**, 329-352.

GREEN, R.K., 2002. Stock Prices and House Prices in California: New Evidence of a Wealth Effect? *Regional Science and Urban Economics,* **32**(6), 775-783.

GUJARATI, D.N., ed, 2003. *Basic econometrics.* 4 edn. New York: McGraw-Hill Higher Education.

HALL, R.E., 1978. Stochastic Implications of the Life Cycle-Permanent Income Hypothesis: Theory and Evidence. *The Journal of Political Economy,* **86**(6), 971-987.

HORT, K., 1998. The Determinants of Urban House Price Fluctuations in Sweden 1968-1994. *Journal of Housing Economics,* **7**(2), 93-120.

JUSELIUS, K., 2008. The Cointegrated VAR model. 1 edn. New York: Oxford University Press.

KAKES, J. and VAN, D.E., 2004. Do Stock Prices Affect House Prices? Evidence for the Netherlands. *Applied Economics Letters,* **11**(12), 741-744.

KAPOPOULOS, P. and SIOKIS, F., 2005. Stock and Real Estate Prices in Greece: Wealth versus 'Credit-Price' Effect. *Applied Economics Letters,* **12**(2), 125-128.

LING, D.C. and NARANJO, A., 1999. The Integration of Commercial Real Estate Markets and Stock Markets. *Real Estate Economics,* **27**(3), 483-515.

LIU, C.H. and MEI, J., 1998. The Predictability of International Real Estate Markets, Exchange Rate Risks and Diversification Consequences. *Real Estate Economics,* **26**(1), 3-39.

LÜTKEPOHL, H., 2007. New Introduction to Multiple Time Series Analysis. Germany: Springer.

NYBERG, L., 2005-12-19. Husprisutvecklingen och penningpolitiken. Speach edn. Evli Bank, Stockholm: www.rixbank.se.

OKUNEV, J., WILSON, P. and ZURBRUEGG, R., 2002. Relationships between Australian Real Estate and Stock Market Prices--A Case of Market Inefficiency. *Journal of Forecasting,* **21**(3), 181-192.

ONG, S.E., 1994. Structural and Vector Autoregressive Approaches to Modelling Real Estate and Property Stock Prices in Singapore. *Journal of Property Finance,* **5**(4), 4-18.

ROTHBARD, M.N., 2008. time preference. *The New Palgrave Dictionary of Economics. Second Edition.*

SIM, S. and CHANG, B., 2006. Stock and Real Estate Markets in Korea: Wealth or Credit-Price Effect. *Journal of Economic Research,* **11**(1), 103-126.

STATISTICS SWEDEN, 2009a-last update [Homepage of Statistics Sweden], [Online]. Available: www.scb.se [04/22, 2009].

STATISTICS SWEDEN, 2009b. *Sveriges officiella statistik, Statistiska meddelanden; FM 20 SM 0901.* Sweden: The Swedish Financial Supervisory Authority.

STATISTICS SWEDEN, 2004. *Wealth statistics 2004.* Sweden: Statistics Sweden.

SUTTON, G.D., 2002. Explaining Changes in House Prices. *BIS Quarterly Review,* , 46-55.

YANG, Z., 2005. Co-integration of Housing Prices and Property Stock Prices: Evidence from the Swedish Market. *Journal of Property Research,* **22**(1), 1-17.

Appendix

Denotations of variables in Stata (V9):

l_stock:	the logged stock price index (OMXS):
lhouse_sweden:	the logged house price index in Sweden
lhouse_sthlm:	the logged house price index in Stockholm County
ltb_3m:	The Swedish three months t-bill, logged
l_GDP:	The Swedish GDP, logged
ce1:	error correction mechanism
D_:	indicates the first difference of the variable is used

Appendix 1: Vector error correction (VEC) test of granger-causality

Since our variables are non-stationary (shown in the Dickey-Fuller test) while their linear combinations are stationary (proved in the Johansen test) we need to use the first differences of all our variables and bas our causality test on the vector error correction model (VEC). We therefore include one error correction mechanism in our model, “ce1” since the Johansen test results indicated one rank in both the model for Sweden and the model for Stockholm (i.e. one cointegration equation). We chose to use a lag of five quarters for both the Swedish data and the Stockholm data, since these lags gave us the lowest Akaike information criteria (see AIC in the output below) out of lag 1-5. We did not test for more than five lags since that would have reduced the degrees of freedom and the explanatory power of our test too much.

The error correction model:

$$\Delta S_t = \sum_{i=1}^{n} \alpha_{1,i}\, \Delta \mathrm{S}_{t-i} + \sum_{i=1}^{n} \beta_{1,i} \Delta H_{t-i} + \sum_{i=1}^{n} \gamma_{1,i}\, \Delta \mathrm{r}_{t-i} + \sum_{i=1}^{n} \delta_{1,i}\, \Delta \mathrm{GDP}_{t-i} + \theta_1 \mathrm{ECM}_{t-1} + \mathrm{u}_{1\mathrm{t}}$$

$$\Delta H_t = \sum_{i=1}^{n} \alpha_{2,i} \Delta\, \mathrm{S}_{t-i} + \sum_{i=1}^{n} \beta_{2,i} \Delta H_{t-i} + \sum_{i=1}^{n} \gamma_{2,i} \Delta\, \mathrm{r}_{t-i} + \sum_{i=1}^{n} \delta_{2,i}\, \Delta \mathrm{GDP}_{t-i} + \theta_2 \mathrm{ECM}_{t-1} + \mathrm{u}_{2\mathrm{t}}$$

$$\Delta r_t = \sum_{i=1}^{n} \alpha_{3,i}\, \Delta \mathrm{S}_{t-i} + \sum_{i=1}^{n} \beta_{3,i} \Delta H_{t-i} + \sum_{i=1}^{n} \gamma_{3,i}\, \Delta \mathrm{r}_{t-i} + \sum_{i=1}^{n} \delta_{3,i}\, \Delta \mathrm{GDP}_{t-i} + \theta_3 \mathrm{ECM}_{t-1} + \mathrm{u}_{3\mathrm{t}}$$

$$\Delta GDP_t = \sum_{i=1}^{n} \alpha_{4,i}\, \Delta \mathrm{S}_{t-i} + \sum_{i=1}^{n} \beta_{4,i} \Delta H_{t-i} + \sum_{i=1}^{n} \gamma_{4,i}\, \Delta \mathrm{r}_{t-i} + \sum_{i=1}^{n} \delta_{4,i}\, \Delta \mathrm{GDP}_{t-i} + \theta_4 \mathrm{ECM}_{t-1} + \mathrm{u}_{4\mathrm{t}}$$

<u>Variables included:</u>

ΔS_t:	First differences of the logged stock price index
ΔH_t:	First differences of the logged house price index
Δr_t:	First differences of the logged real interest rate
ΔGDP_t:	First differences of the logged GDP
ECM:	the error correction term that expresses the included variables interrelationship. It is derived as the residual from the simple regression with the two cointegrated variables
$\alpha_{x,i}$; $\beta_{x,i}$; $\gamma_{x,i}$; $\delta_{x,i}$; θ_x :	Coefficients with row: *x* and lag length: *i* (*i*=1, 2,…, n)

The granger-causality test:

Do house prices granger-cause stock prices in Sweden/Stockholm when the GDP and the interest rate are accounted for as well as the variables’ interrelationships?

H_0: $\beta_{1,i} = 0$ (indicating *no* causal relationship)
H_1: $\beta_{1,i} \neq 0$ (indicating a causal relationship)

Do stock prices granger-cause house prices in Sweden/Stockholm when the GDP and the interest rate are accounted for as well as the variables’ interrelationships?

H_0: $\alpha_{2,i} = 0$ (indicating *no* causal relationship)
H_1: $\alpha_{2,i} \neq 0$ (indicating a causal relationship)

SWEDEN

. vec l_stock lhouse_sweden ltb_3m l_GDP, lags(5) rank(1)

Vector error-correction model

Sample: 1993q2   2009q1   No. of obs   =   64
AIC = -13.99422
Log likelihood =   522.815   HQIC   = -12.99755
Det(Sigma_ml) = 9.43e-13   SBIC   = -11.46428

Equation	Parms	RMSE	**R-sq**	chi2	P>chi2
D_l_stock	18	.123223	**0.3078**	20.45294	0.3079
D_lhouse_sweden	18	.012462	**0.8024**	186.7966	0.0000
D_ltb_3m	18	. 122106	0.7024	108.5753	0.0000
D_l_GDP	18	.012264	0.9759	1862.388	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% CI]	
D_l_stock						
_ce1						
L1.	.0047179	.0241097	0.20	0.845	-.0425363	.051972
l_stock						
LD.	.1244617	.147937	0.84	0.400	-.1654894	.4144128
L2D.	.1064864	.1520422	0.70	0.484	-.1915108	.4044836
L3D.	**.3465294**	**.1553531**	**2.23**	**0.026**	**.0420429**	**.6510159**
L4D.	-.0713088	.1530394	-0.47	0.641	-.3712605	.2286429
lhouse_swe~n						
LD.	-2.169102	1.422435	-1.52	0.127	-4.957024	.6188199
L2D.	-.3290821	1.49006	-0.22	0.825	-3.249547	2.591383
L3D.	-.8581629	1.586884	-0.54	0.589	-3.968399	2.252073
L4D.	1.720677	1.512748	1.14	0.255	-1.244255	4.685609
ltb_3m						
LD.	.0329798	.2100201	0.16	0.875	-.3786521	.4446117
L2D.	-.3871013	.244444	-1.58	0.113	-.8662028	.0920002
L3D.	-.1014675	.1983546	-0.51	0.609	-.4902354	.2873004
L4D.	-.113213	.1811819	-0.62	0.532	-.468323	.241897
l_GDP						
LD.	.678438	1.263689	0.54	0.591	-1.798348	3.155224
L2D.	.7254614	1.501514	0.48	0.629	-2.217451	3.668374
L3D.	.6080624	1.408054	0.43	0.666	-2.151673	3.367798
L4D.	.3889121	1.24388	0.31	0.755	-2.049049	2.826873
_cons	-.0253023	.1119011	-0.23	0.821	-.2446245	.1940198
D_lhouse_s~n						
_ce1						
L1.	.0037731	.0024383	1.55	0.122	-.0010059	.0085522
l_stock						
LD.	**.0361502**	**.0149616**	**2.42**	**0.016**	**.006826**	**.0654744**
L2D.	**.0320698**	**.0153768**	**2.09**	**0.037**	**.0019319**	**.0622077**
L3D.	.0090272	.0157116	0.57	0.566	-.021767	.0398214
L4D.	.0141252	.0154776	0.91	0.361	-.0162103	.0444608
lhouse_swe~n						
LD.	**.3127939**	**.1438579**	**2.17**	**0.030**	**.0308376**	**.5947501**
L2D.	**-.2722497**	**.1506971**	**-1.81**	**0.071**	**-.5676106**	**.0231113**
L3D.	.0794881	.1604894	0.50	0.620	-.2350653	.3940415
L4D.	.1996062	.1529917	1.30	0.192	-.100252	.4994643
ltb_3m						
LD.	-.0179755	.0212404	-0.85	0.397	-.0596059	.0236549
L2D.	.0157882	.0247218	0.64	0.523	-.0326657	.064242
L3D.	-.0157651	.0200606	-0.79	0.432	-.0550831	.0235529
L4D.	-.0210726	.0183238	-1.15	0.250	-.0569866	.0148414
l_GDP						
LD.	.0308715	.1278031	0.24	0.809	-.219618	.281361

```
         L2D. |  .0837489   .1518554     0.55   0.581    -.2138823    .3813801
         L3D. | -.0646808   .1424034    -0.45   0.650    -.3437864    .2144248
         L4D. | -.1188289   .1257997    -0.94   0.345    -.3653918    .1277341
        _cons | -.0087782   .0113171    -0.78   0.438    -.0309593    .0134029
-------------+----------------------------------------------------------------
D_ltb_3m     |
         _ce1 |
          L1. | -.0387136   .0238912    -1.62   0.105    -.0855395    .0081123
      l_stock |
          LD. |  .3148351   .1465964     2.15   0.032     .0275114    .6021589
         L2D. | -.0281474   .1506645    -0.19   0.852    -.3234443    .2671495
         L3D. |  .0682631   .1539454     0.44   0.657    -.2334643    .3699905
         L4D. |  .0862412   .1516526     0.57   0.570    -.2109924    .3834749
lhouse_swe~n |
          LD. |    1.3676   1.409546     0.97   0.332    -1.395059    4.130259
         L2D. |  2.021266   1.476558     1.37   0.171    -.8727342    4.915267
         L3D. | -1.704734   1.572504    -1.08   0.278    -4.786786    1.377318
         L4D. |   3.57389    1.49904     2.38   0.017     .6358247    6.511955
       ltb_3m |
          LD. |  .9130888    .208117     4.39   0.000     .5051869    1.320991
         L2D. | -.8013155    .242229    -3.31   0.001    -1.276076   -.3265555
         L3D. |  .3953776   .1965572     2.01   0.044     .0101326    .7806227
         L4D. | -.2804043   .1795401    -1.56   0.118    -.6322964    .0714879
        l_GDP |
          LD. |  2.831014   1.252238     2.26   0.024     .3766723    5.285357
         L2D. |  1.603507   1.487907     1.08   0.281    -1.312738    4.519752
         L3D. |  .8477163   1.395295     0.61   0.543    -1.887011    3.582444
         L4D. |  1.792754   1.232609     1.45   0.146    -.6231155    4.208623
        _cons | -.0188936   .1108871    -0.17   0.865    -.2362283    .1984412
-------------+----------------------------------------------------------------
D_l_GDP      |
         _ce1 |
          L1. | -.0104044   .0023996    -4.34   0.000    -.0151076   -.0057013
      l_stock |
          LD. |   .048145   .0147241     3.27   0.001     .0192864    .0770036
         L2D. |  .0233208   .0151326     1.54   0.123    -.0063386    .0529803
         L3D. |  .0034926   .0154622     0.23   0.821    -.0268127    .0337979
         L4D. | -.0230459   .0152319    -1.51   0.130    -.0528999     .006808
lhouse_swe~n |
          LD. | -.0075408   .1415739    -0.05   0.958    -.2850205    .2699389
         L2D. |  .4304475   .1483046     2.90   0.004     .1397759    .7211191
         L3D. |  .2409554   .1579414     1.53   0.127     -.068604    .5505147
         L4D. |  .3387456   .1505627     2.25   0.024     .0436482     .633843
       ltb_3m |
          LD. |  .0296839   .0209031     1.42   0.156    -.0112855    .0706533
         L2D. | -.0283489   .0243293    -1.17   0.244    -.0760335    .0193357
         L3D. |  .0350118   .0197421     1.77   0.076     -.003682    .0737056
         L4D. | -.0225561   .0180329    -1.25   0.211    -.0578999    .0127877
        l_GDP |
          LD. | -.5442759    .125774    -4.33   0.000    -.7907885   -.2977633
         L2D. | -.4220552   .1494445    -2.82   0.005     -.714961   -.1291494
         L3D. | -.4841281   .1401425    -3.45   0.001    -.7588024   -.2094537
         L4D. |  .2940047   .1238025     2.37   0.018     .0513563    .5366531
        _cons |  .0556435   .0111374     5.00   0.000     .0338146    .0774725

-------------------------------------------
```

STOCKHOLM

. vec l_stock lhouse_sthlm ltb_3m l_GDP, lags(5) rank(1)

Vector error-correction model

```
Sample:  1993q2   2009q1                  No. of obs      =        64
                                          AIC             =  -13.3202
Log likelihood =  501.2464                HQIC            = -12.32353
Det(Sigma_ml)  =  1.85e-12                SBIC            = -10.79026
```

Equation	Parms	RMSE	**R-sq**	chi2	P>chi2
D_l_stock	18	.118848	**0.3561**	25.43489	0.1134
D_lhouse_sthlm	18	.017091	**0.7932**	176.3836	0.0000
D_ltb_3m	18	.1315	0.6549	87.2789	0.0000
D_l_GDP	18	.013328	0.9715	1569.989	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% CI]	
D_l_stock						
_ce1						
L1.	-.1122861	.1051226	-1.07	0.285	-.3183226	.0937504
l_stock						
LD.	.2046161	.1663551	1.23	0.219	-.1214339	.5306661
L2D.	.2603376	.1693721	1.54	0.124	-.0716256	.5923008
L3D.	**.3819955**	**.1526505**	**2.50**	**0.012**	**.082806**	**.681185**
L4D.	-.0538591	.1487078	-0.36	0.717	-.345321	.2376028
lhouse_sthlm						
LD.	-.5784551	1.058479	-0.55	0.585	-2.653035	1.496125
L2D.	-1.35416	1.056948	-1.28	0.200	-3.42574	.7174204
L3D.	.564255	1.031469	0.55	0.584	-1.457387	2.585897
L4D.	1.527174	1.0203	1.50	0.134	-.4725775	3.526926
ltb_3m						
LD.	.0836207	.2030329	0.41	0.680	-.3143165	.481558
L2D.	-.1908684	.2271683	-0.84	0.401	-.6361101	.2543733
L3D.	-.1534883	.1932113	-0.79	0.427	-.5321755	.2251989
L4D.	.0053324	.1861342	0.03	0.977	-.3594839	.3701486
l_GDP						
LD.	-.6849748	1.437391	-0.48	0.634	-3.502209	2.13226
L2D.	-.8158682	1.646251	-0.50	0.620	-4.042461	2.410725
L3D.	-.4865356	1.481109	-0.33	0.743	-3.389456	2.416385
L4D.	-.6627013	1.277235	-0.52	0.604	-3.166035	1.840632
_cons	-.0440431	.0789015	-0.56	0.577	-.1986873	.110601
D_lhouse_s~m						
_ce1						
L1.	**.0461603**	**.0151174**	**3.05**	**0.002**	**.0165308**	**.0757899**
l_stock						
LD.	.0264112	.0239231	1.10	0.270	-.0204771	.0732996
L2D.	**.0409195**	**.0243569**	**1.68**	**0.093**	**-.0068192**	**.0886582**
L3D.	.003297	.0219522	0.15	0.881	-.0397286	.0463226
L4D.	.0301874	.0213853	1.41	0.158	-.0117269	.0721017
lhouse_sthlm						
LD.	.2418557	.1522169	1.59	0.112	-.0564839	.5401952
L2D.	**-.4322674**	**.1519968**	**-2.84**	**0.004**	**-.7301756**	**-.1343592**
L3D.	.1734843	.1483327	1.17	0.242	-.1172424	.464211
L4D.	-.1102516	.1467265	-0.75	0.452	-.3978304	.1773271
ltb_3m						
LD.	-.0358585	.0291976	-1.23	0.219	-.0930847	.0213678
L2D.	-.01612	.0326684	-0.49	0.622	-.080149	.0479089
L3D.	-.0343724	.0277852	-1.24	0.216	-.0888304	.0200855
L4D.	-.0309093	.0267674	-1.15	0.248	-.0833726	.0215539
l_GDP						
LD.	.3297817	.2067072	1.60	0.111	-.0753569	.7349203
L2D.	**.4964632**	**.2367428**	**2.10**	**0.036**	**.0324559**	**.9604705**
L3D.	.1987207	.2129941	0.93	0.351	-.2187402	.6161815
L4D.	.0842883	.1836755	0.46	0.646	-.2757091	.4442858
_cons	.032708	.0113466	2.88	0.004	.0104691	.054947
D_ltb_3m						
_ce1						
L1.	.0462034	.1163135	0.40	0.691	-.1817668	.2741737
l_stock						
LD.	.1883731	.1840646	1.02	0.306	-.1723869	.5491331
L2D.	.0454126	.1874027	0.24	0.809	-.32189	.4127152

L3D.	.1265605	.1689011	0.75	0.454	-.2044795	.4576005
L4D.	.1385996	.1645386	0.84	0.400	-.1838902	.4610893
lhouse_sthlm						
LD.	.2713275	1.17116	0.23	0.817	-2.024104	2.566759
L2D.	-.2920806	1.169467	-0.25	0.803	-2.584193	2.000032
L3D.	-.8231579	1.141275	-0.72	0.471	-3.060015	1.4137
L4D.	1.16358	1.128917	1.03	0.303	-1.049058	3.376217
ltb_3m						
LD.	**.9365344**	**.224647**	**4.17**	**0.000**	**.4962344**	**1.376834**
L2D.	**-.8483708**	**.2513517**	**-3.38**	**0.001**	**-1.341011**	**-.3557305**
L3D.	.3061158	.2137798	1.43	0.152	-.1128849	.7251165
L4D.	-.3005814	.2059492	-1.46	0.144	-.7042345	.1030717
l_GDP						
LD.	**2.898471**	**1.59041**	**1.82**	**0.068**	**-.2186744**	**6.015617**
L2D.	2.486451	1.821504	1.37	0.172	-1.083632	6.056533
L3D.	2.474819	1.638782	1.51	0.131	-.737134	5.686772
L4D.	**2.832899**	**1.413204**	**2.00**	**0.045**	**.0630704**	**5.602727**
_cons	-.1406684	.0873011	-1.61	0.107	-.3117753	.0304385
D_l_GDP						
_ce1						
L1.	**-.0297608**	**.0117885**	**-2.52**	**0.012**	**-.0528658**	**-.0066557**
l_stock						
LD.	**.0646156**	**.0186552**	**3.46**	**0.001**	**.0280522**	**.1011791**
L2D.	.0295559	.0189935	1.56	0.120	-.0076707	.0667824
L3D.	.0089342	.0171183	0.52	0.602	-.0246171	.0424854
L4D.	-.0153917	.0166762	-0.92	0.356	-.0480764	.017293
lhouse_sthlm						
LD.	-.0134093	.1186984	-0.11	0.910	-.2460539	.2192353
L2D.	.1418236	.1185268	1.20	0.231	-.0904847	.3741318
L3D.	**.2787645**	**.1156695**	**2.41**	**0.016**	**.0520564**	**.5054725**
L4D.	.0692487	.1144171	0.61	0.545	-.1550047	.293502
ltb_3m						
LD.	**.0557344**	**.0227682**	**2.45**	**0.014**	**.0111095**	**.1003593**
L2D.	-.0281769	.0254748	-1.11	0.269	-.0781065	.0217528
L3D.	**.0422128**	**.0216668**	**1.95**	**0.051**	**-.0002534**	**.084679**
L4D.	-.0172094	.0208732	-0.82	0.410	-.0581201	.0237013
l_GDP						
LD.	**-.7008209**	**.1611899**	**-4.35**	**0.000**	**-1.016747**	**-.3848946**
L2D.	**-.4902544**	**.1846116**	**-2.66**	**0.008**	**-.8520864**	**-.1284224**
L3D.	**-.4981237**	**.1660924**	**-3.00**	**0.003**	**-.8236588**	**-.1725885**
L4D.	**.2795396**	**.1432298**	**1.95**	**0.051**	**-.0011857**	**.5602649**
_cons	-.0014824	.0088481	-0.17	0.867	-.0188243	.0158595

Result: The null hypothesis is rejected at a 10 percent level for both Sweden and Stockholm. The significant coefficients, with p-values<0.10, are made bold in the tables above (see column P>|z|). The final models that only include the variables with significant explanatory power are presented below.

Final model: Sweden

$\Delta S_t = \alpha_{1,3}\Delta S_{t-3} + u_{1,t}$

$\Delta H_t^{SW} = \alpha_{2,1}\Delta S_{t-1} + \alpha_{2,2}\Delta S_{t-2} + \beta_{2,1}\Delta H_{t-1}^{SW} + \beta_{2,2}\Delta H_{t-2}^{SW} + u_{2,t}$

$\Delta r_t = \alpha_{3,1}\Delta S_{t-1} + \beta_{3,4}\Delta H_{t-4}^{SW} + \gamma_{3,1}\Delta r_{t-1} + \gamma_{3,2}\Delta r_{t-2} + \gamma_{3,1}\Delta r_{t-3} + \delta_{3,1}\Delta GDP_{t-1} + u_{3,t}$

$\Delta GDP_t = \alpha_{4,1}\Delta S_{t-1} + \beta_{4,2}\Delta H_{t-2}^{SW} + \beta_{4,4}\Delta H_{t-4}^{SW} + \gamma_{4,3}\Delta r_{t-3} + \delta_{4,1}\Delta GDP_{t-1} + \delta_{4,2}\Delta GDP_{t-2} + \delta_{4,3}\Delta GDP_{t-3} + \delta_{4,4}\Delta GDP_{t-4} +$
$\theta 2ECM\, t-1 + u4,t$

Final model: Stockholm

$\Delta S_t = \alpha_{1,3}\Delta S_{t-3} + u_{1,t}$

$\Delta H_t^{St} = \alpha_{2,2}\Delta S_{t-2} + \beta_{4,2}\Delta H_{t-2}^{St} + \delta_{2,2}\Delta GDP_{t-2} + \theta_2 ECM_{\,t-1} + u_{2,t}$

$\Delta r_t = \gamma_{3,1}\Delta r_{t-1} + \gamma_{3,2}\Delta r_{t-2} + \delta_{3,1}\Delta GDP_{t-1} + \delta_{3,4}\Delta GDP_{t-4} + u_{3,t}$

$\Delta GDP_t = \alpha_{4,1}\Delta S_{t-1} + \beta_{4,3}\Delta H_{t-3}^{St} + \gamma_{4,1}\Delta r_{t-1} + \gamma_{4,3}\Delta r_{t-3} + \delta_{4,1}\Delta GDP_{t-1} + \delta_{4,2}\Delta GDP_{t-2} + \delta_{4,3}\Delta GDP_{t-3} +$
$\delta 4,4\Delta GDPt-4 + \theta 4ECM\, t-1 + u4,t$

Appendix 2: The impulse-response function

SWEDEN: Impulse-response function, impulse in stock, response in house

. irf table, impulse (l_stock) response (lhouse_sweden)

Results from Irf_SW

step	**irf**
0	0
1	.039923
2	.089975
3	.113869
4	**.129201**
5	.12153
6	.10359
7	.082904
8	.048949
9	.010642
10	-.010962
11	-.014925
12	-.006881

irfname = Irf_SW, impulse = l_stock, and response = lhouse_sweden

STOCKHOLM: Impulse-response function, impulse in stock, response in house

. irf table, impulse (l_stock) response (lhouse_sthlm)

Results from Irf_Sthlm

step	(1) irf
0	0
1	.072572
2	.186209
3	.240683
4	**.284269**
5	.283832
6	.252438
7	.238888
8	.211832
9	.192345
10	.203131
11	.223295
12	.243963

(1) irfname = Irf_Sthlm, impulse = l_stock, and response = lhouse_sthlm

Result: For both Stockholm and Sweden, our estimated model suggests that an impulse from the stock market prices yields a positive response in the housing prices. Point estimates indicate that in Sweden, housing prices change by 1.3 percent over one year, following a shock in stock prices of ten percent. In Stockholm, a similar shock in stock prices generates a change in house prices by 2.8 percent in the same direction.