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Financial Economics

The Impact of Interest Changes on Housing Prices

Bachelor thesis 15 HP

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ABSTRACT

The study examines the relationship of interest rates and housing prices. It does so for Sweden as a nation as well as the cities Stockholm and Gothenburg. The interaction of housing prices and interest rates is examined by using the Johansen tests for cointegration and the vector error correction model. Several studies have been conducted on this topic across the globe, but not many in Scandinavia, and not using the same time-frame. This thesis contributes to the literature by studying quarterly data between 1996 and 2019, capturing two economic cycles. We find evidence of long-run and short-run interactions between the interest and housing prices. The results showed evidence of a negative relationship between housing prices and the interest rate. Furthermore, we found that Stockholm housing prices is more sensitive to interest rate changes compared to the nation and Gothenburg.

1. Contents

1. Introduction

1.1. Background

For young people in Sweden, purchasing their first home is notoriously difficult in the housing market. According to SBAB, a Swedish mortgage bank, it's nearly impossible for the average person below the age of 30 (Claudia Wörmann, 2018). The difficulty stems from soaring home prices in relation to wage increases. In the media, journalists often say that prices have soared due to a lack of home building, the demand far exceeds supply. Additionally, blame is cast at the dysfunctional rental market. The waiting list for a rental lease is currently at 20 years in the Swedish capital, Stockholm (Savage, 2016). While it is fair to assume both the lack of building and dysfunctional renting market has an impact, the effect of plummeting interest rates has not been given enough attention.

Data reported from 90% of Sweden's real estate brokerages, shows that the prices of real estate in Sweden have increased at a compounded annual growth rate of 6.1% between 1996-2019, measured by the purchasing coefficient (K/T-ratio) (Mäklarstatistik, 2020). During the same time-period, the price per square meter for apartments has increased by 9.2% CAGR[1]. This results in an increase of 293% and 661% respectively for the 23-year period, far outpacing the inflation of 30.6% over the same period (SCB, 2020) and the real GDP growth of 52.4% (Louis, 2020)

Data from SCB (2020) shows that in 1996 the household debt level in relation to the household's disposable income were 94%. In the last quarter of 2019, the same number were 187%. Over the last 23 years, households have roughly doubled their debt over income level. Despite this, during the same time span, interest expenses in relation to disposable income have more than halved from 9.6% to 4%. The lower interest rates have benefited homeowners, but the rising home prices haves an adverse effect on young people. As most new and high wage jobs are found in the main cities, in addition to the highest ranked universities, the current state of the housing market is in effect hold back younger people from pursuing higher education and career opportunities. The situation got grimmer after the introduction

[1] Compound Annual Growth Rate

of the Swedish 'amorteringskrav' which states how much of the loan you must pay back per annum.

The common perception in Swedish news media is that interest rates are affecting housing prices. In an interview with the Swedish business site, Privata Affärer, SBAB:s chief economist stated that housing prices are likely to decrease due to increasing mortgage rates (Boije, 2018). In an article from Dagens Nyheter, low interest rates were blamed for increased economical gaps because lower interest rates boost, among other assets, housing prices (2017). It is interesting that the medial- and scientific field differ in their view of a subject that is important for a large proportion of the society.

1.2. Problem Definition and Analysis

Despite the vast research done on the effect of interest rates on housing prices, there is a lack of research focusing on the effect over a longer time horizon, including several market cycles with different conditions and characteristics.

Previous studies that analysed housing prices found that the most important determination for housing prices is the publics underlying expectation of further increases (Harris, 1989) (Wong, Hui, & Seabrooke, 2003) (Wong, Hui, & Seabroke).

1.3. Purpose

This thesis aims to identify whether Swedish housing prices are explained by the changes in mortgages rates, and if so to what extent. What effects would an increase or decrease of mortgage rates have on house prices? If no correlation between mortgage rates and housing prices are found, what are the causes behind this, and which of our control variables are deterministic? Hopefully, the results of the study will add to the understanding of the importance of mortgage rates on housing prices.

1.4. Time Span

By looking at data between 1996 and 2019, enables studying housing market over more than one cycle. In 1996, Sweden was almost fully recovered after the 1990 crash and the subsequent recession. Late 1990s was characterized by the IT hysteria and optimism over the future, while the crash that followed in 2000 dampened the mood. During 2000s, the worst global financial crisis since the Great Depression occurred, with the subsequent low interest rate environment. In early 2010s, the Euro Crisis hits most of Europe hard and further fuels low interest rates.

1.5. Delimitations

Although first time buyers are more likely to purchase a condominium than a house, this thesis investigated the impact of mortgage rates on housing prices because quarterly condominium prices are only available from 2005 and forward via the HOX-index (2020). There are several studies on the impact of mortgage rates on the HOX-index, and another one would not add significantly to the common pool of knowledge. This bachelor thesis analysed data between 1996 and 2019.

2. Theory Review

The purpose of this chapter was to identify the theoretical base and previous studies in the interest rate, housing prices area. Additionally, some light will be shed at a few of the shortfalls in the current research.

2.1. Theoretical Shortfalls

Several research studies related to the subject interest rate housing prices have been done. However, due to the extent of the field, there are millions of submarkets and combination of time periods. Furthermore, there has been a tendency to just look at prices over one full cycle.

2.2. Complementary Goods

According to microeconomic theory, an increase in the prices of complementary goods or services will decrease the demand for the observed good or service (Hashimzade, Myles, & Black, 2017). Mortgage loans are a complementary good to housing prices because the lower the interest rate, the cheaper it is to borrow. In a paper published in the Journal of Real Estate, Finance and Economics, Jack C. Harris (1989) states: "The demand for most goods declines when the cost of complementary goods rises. Therefore, one would expect the market price of housing to decrease because of weakened demand as the cost of mortgage financing increase."

2.3. Competitive Goods

Microeconomic theory predicts lower demand for the observed good or service if the price of a competitive good decreases. If there is a sudden influx of affordable rental properties in the market, the demand for buying a house should decrease.

2.4. Supply and Demand

The equilibrium price of housing is based upon the intersection of supply and demand. With the assumption that the supply side of all types of housing is to be sticky in the short term, as construction of both new houses and rental property takes time. In addition, the supply side of houses is expected to be negatively correlated with interest rates, as cheaper mortgages will make house ownership relatively attractive compared to renting. Homeowners selling their home could be considered supply, but the anticipation is that most people buy another house. Furthermore, as stated previously, owning will become cheaper in both absolute and relative terms. There is also the lock-in effect that occurs when people have large capital gains on their real estate, something that Hemnet, the largest portal for displaying homes for sale in Sweden, reported in 2017 (Granath). Therefore, the expectation of a negative correlation between supply and interest rates is assumed. The demand side is expected to shift in the short term as interest rates and preferences are expected to affect buyers instantaneously. Hence, this theoretical framework suggests that housing prices are based on supply and demand in the short term. The main variable affecting the demand is assumed to be the cost of owning a home. The main costs are paying the mortgage. Basic theory on elasticity of demand suggests that when the costs of owning a home decreases, the demand of owning a home increases as rentals become relatively expensive.

2.5. Population

One important aspect of the demand situation is the population. In the short run an influx of new people would lead to demand shock, increasing the demand for all types of housing and push the prices upwards. Eventually, supply will catch up when more properties are built.

2.6. Real GDP Growth

Real GDP growth means that people can afford to purchase more goods and services than previously. This should lead to an increase in housing prices as people have the means to pay more for a house. However, in an article from 2010, a team of researchers in Taiwan found that GDP growth caused inflation without causing growth in housing prices (Nguyen & Wang). However, in a paper by Lina Karpaviciute, it was stated that the most common determinant of house prices are, among others, real GDP (2017).

2.7. Wealth Effect

It has been observed that as total wealth of an individual increases the person is more inclined to spend a larger proportion of current income and save less (Manley, Foot, & Davis, 2019). Simultaneously, an increase in house prices will at the same time increase the wealth of the owner (Bernardina, 2013). As the owner feels richer, he or she is less inclined to save money, something that may lead to the pursuit of a more expensive house. Based on the wealth effect, if house prices nationwide increased at the same time, the amplitude of the increase should be boosted by the wealth effect. The enhancing effect should therefore lead to larger movement in housing prices than what we attribute to interest rate effects alone.

2.8. Disposable income

Consider an individual with a mortgage loan, part of her income is spent on interest payments. When the mortgage rates increase, the individual's disposable income net interest payments would decrease. As it gets more expensive to borrow, with the presumption that mortgage is a normal good, the demand for mortgages decreases. Depending on the elasticity of demand for mortgages, interest expenses to disposable income do not necessarily have to decrease. If mortgage rates were to decrease, the opposite of the above would be true.

2.9. Expected Results of the Study

Our hypothesis was that housing prices, to a certain degree, is explained by supply and demand effects and that real interest rates are determinative for housing prices. Lower interest rates lead to lower costs of mortgages. Therefore, people can increase their loan size while retaining an equal monthly mortgage cost. It would imply that buyers are able and willing to take on more debt and pay more for housing. Hence, a negative correlation between interest rate and housing prices is expected. Homeowners do not focus on the nominal value of their mortgages, but rather the monthly cash-flow effects of amortization and interest payments. A study, performed between January 2007 and October 2010, indicated that the assumption may be well founded, and showed a correlation of -0.812 between interest rates and housing prices (Nissim, 2012).

3. Literature Review

3.1. Nordic Research

The volatile real estate prices of the last few years have led to a discussion on the role of central banks regarding price stability. In a study conducted by Carjias & Ertl (2017), the authors claimed that housing prices are characterized by long adjustment phases and that the housing market has a large impact on the household's debt position and the countries aggregated demand. In this report, the authors investigated the relationship of long- and short-term interest rates on housing prices. The authors found evidence of a positive relation between a growth of macroeconomic output and housing prices. In Sweden, a macroeconomic shock of one percent leads to a 0.7 percent increase in housing prices. Furthermore, Carjias & Ertl (Cajias, 2017) found a negative correlation between the interest rates and housing prices in the Nordics. However, the correlation was against expectations positive for Sweden, meaning that the price is inelastic housing demand to financing costs (Cajias, 2017).

A study by the Swedish Riksbank's Carl Andreas Claussen (2013) found that the increase in housing prices can be attributed to as much as 25% by real interest rates. However, the lion's share, 62%, is attributed to increases in real disposable income with the rest, 8%, explained by real financial wealth. The study predicted housing prices to be relatively stable in the coming years, an analysis that turned out to be wrong. The observed time period ended right before the real monetary stimulus began. It is likely that a larger extent of housing prices increases is attributed to interest rates in the last five to ten years.

3.2. Expectation is Key

In a paper by Jack C. Harris (1989) it was revealed that in the short-run there were no correlations between nominal interest rates and housing prices. This contrasts to the microeconomic models that predict that a price increases of a complimentary good should lead to a decline in the demand for the observed good. Harris gave several explanations why 1970s housing markets behaved in this way. First, people saw buying a home as a protection against the highly inflationary economy of the 70s and a way to lock in housing costs. Furthermore, high interest rates led to substantial federal tax cuts for interest expenses. In addition, most rental agreements have an inflationary clause, i.e. rent is determined by price-levels, resulting in higher rent in high inflationary periods. When owning a home, inflation is beneficiary by making the real value of the loan smaller each year. These effects increased the demand for homes, leading to higher housing prices, according to Harris.

Harris' findings were supported by a study published in 2003 where Wong, Hui & Seabrooke (The Role of Interest Rates in Influencing Housing Prices) found that real interest rates alone did not determine housing prices in Hong Kong between 1981 and 2001. Their results suggested that even if real interest rates declined buyers believed that the market outlook were grim, housing prices would decline. The authors stated that the market is forward looking, driven by optimistic investors. In this study they argue that investors saw deflation during 1998-2001, leading to low hope of rent and increased house prices. It did not matter that real interest rates turned negative, the prospect capital losses when reselling the house out wage the cheap financing. Their conclusion was that the most important thing for determining housing prices are nominal interest rates and expected capital gains/losses.

3.3. Long Run Studies

In a study from 2004, James M. McGibany & Farrokh Nourzad (2010)set out to find if lower mortgage rates meant higher housing prices. The study investigated new single-family housing prices between 1963 and 1997 in the US. The authors found that in the short run there was barely no relationship between mortgage rates and housing prices. This is in line with the previous research (Wong, Hui, & Seabrooke, 2003) (Harris, 1989). In the long run however, the study found that housing prices had a rather inelastic response to mortgage rates, with an elasticity of -.0789. Other studies mentioned in the article found an elasticity between mortgage rates and housing prices of -0.069 and –0.086, for the UK and Ireland, respectively.

The findings of McGibany and Nourzad affirms the notion that housing prices in the short run are driven by other factors than mortgage rates.

Maher Asal (2018) analysed the drivers behind the long-run house price increases in Sweden. Asal included data between 1986 and 2006 and found several factors behind the price increase:

- Low repo rate (that in turn drew down the mortgage rates)
- Structural factors such as housing supply constraints and tax benefits
- Improvements in Sweden's competitiveness relative to foreign economies

Although Asal did quantify the correlation between mortgage rates and interest rates, her findings for Sweden is in line with what have been found abroad.

3.4. Evidence of Cointegration

Studies of the housing market has found evidence of cointegration across multiple regions. Data from Denmark by Knudsen and Temere (2016) finds that real buyer costs and real housing prices are cointegrated when including dwelling stock and inflation. Moreover, they found that an increase in user cost, for example an increase in interest rates, leads to a shift in demand and consequently a decline in housing prices. In addition, as an effect of this, the housing stock declines, which then puts pressure on the price of housing to increase. In the long term, they found that there was no effect on housing prices, but the housing stock was permanently lower due to the user cost increase.

Similarly, MartÌnez-Carrascal (2009) found evidence of cointegration while analysing data of the Spanish housing market. She found that in the long run housing prices and the level of borrowing are cointegrated. High housing prices and high lending volumes were positively correlated as the houses acts as collateral for the loans. She argued that better financing conditions leads to more indebtedness, which, as stated above, leads to higher housing prices.

Zan Yang and S.T. Wang (2012) found that interest rates play a dominant role in explaining Swedish house price changes. In addition, they found that interest rates have a dominant role in explaining user costs for households. They found evidence of one cointegrating relationship while including consumption expenditure per capita, user cost of housing and house prices. The results of their study show that permanent interest shocks account for 72-94 percent of the long-run variations in housing prices.

4. Data

4.1. Data Collection

The study was based on quarterly data from 1996 to 2019, which equals 96 observations. Additional historic data would have been beneficial. However, the quality and frequency of data collection was insufficient before 1996. The frequency of quarters is beneficial in identifying short- and long-term effects. The availability of yearly data is better than quarterly data. However, the amount of observations and the analysis of short-term relationships would have been weaker. The use of monthly data was pursued but abandoned due to the lack of available data.

The data used in the analysis is secondary data. It was gathered from Statistiska Centralbyrån (SCB) and the Federal Reserve. The quality Collection of primary data would have been of lower quality and hard to collect under the limited time frame of the study. The collected data was presented in tables by the source in a way fit for further analysis. Hence, the risk of error during data collection was limited.

4.2. Variable Selection

The number of variables influencing housing prices are many. Specifying the true model which captures all variables correctly is unrealistic. Furthermore, the multicollinearity of economic data presents an obstacle for including all variables which could impact the price of housing. The model is specified to capture the key aspects of house pricing without introducing damaging multicollinearity.

Table 1. *Variables included in model*

Variable	Definition
Y	Housing Prices
X1	Mortgage Rate
X2	Consumer Price Index
X3	Finished Housing Units
X4	Real GDP

4.2.1. Housing Prices

The housing prices data is presented by SCB and Macrobond on a quarterly basis. The data presented shows the average pricing level of small houses for the predetermined period in Sweden. Small housing means one family homes. Housing prices for condominiums could have been used in addition to small housing. Condominium data is presented by the HOX-index. However, the time frame for the HOX-index is limited to 2005. Furthermore, the data presented in the HOX-index has been widely studied. Another analysis of the same data set would have been of less value.

Analysing housing prices through the small housing index is a viable proxy for condominiums as well. If the price of housing increases, the nature of competitive goods should lead to an increase in condominium prices.

The econometric analysis has been applied to data of national prices, Stockholm prices and Gothenburg prices. The use of the three data sets enables insights of potential regional differences in variable response.

4.2.2. Mortgage Rate

The mortgage rate data is presented by SCB on a monthly basis and was converted into quarterly data using the average rate of the three months during the quarter. The data is the average mortgage rate of outstanding loans, issued by mortgage lenders. The most common type of mortgage rate is floating. The average is reflective of the financing rate for new loans. By using the average of all loans rather than new loans means that it also captures the effect of forced downsizing due to higher financing costs. It captures the supply and demand effect of changes in mortgage rates.

Using the nominal rate rather than the real rate could be problematic. An increase of inflation results in an equal increase of interest rates according the Fisher effect. Inflation influences the consumer price index, a variable used within the model. This means that the mortgage rate is correlated with the consumer price index through inflation. However, using the real interest rate would not capture the immediate cash flow effect which home-owners would experience. The nominal interest rate has a clearer link to the perceived cost changes of housing by home-owners.

4.2.3. Consumer Price Index

The Consumer price index data is presented by SCB on a monthly basis and was converted into quarterly data using the averages of the month within the corresponding quarter. It shows the indexed average price level of goods & services for the period. An increase of the index means that the price of goods and generally the income level for domestic residents has increased in nominal terms. The price of goods must be considered competitive to the price of housing. If the average cost of goods is higher, housing is cheaper in relative terms. Furthermore, if income increases in nominal terms, buyers of homes can spend more on mortgages and qualifies for a larger loan volume.

4.2.4. Finished Housing Units

The finished housing unit data is presented by SCB on a quarterly basis. It includes finished units of condominiums and houses. An increase of housing units shifts the intersection of supply and demand for housing, leading to lower housing prices in theory. Additionally, finished units indicates the state of the economy. The willingness to invest and the access to capital could be reflected through building activity and in turn, with a lag, finished units.

4.2.5. Real GDP per Capita

The real GDP data is presented by the Federal Reserve Bank of St. Louis on a quarterly basis. The data was seasonally adjusted using Stata. In addition, data was adjusted by dividing the real GDP with the population of Sweden. The adjustment is necessary to minimise the multicollinearity of real GDP and population. The real GDP is reflective of productivity levels. An increase in real GDP means that more goods are produced. This will result in increased wages as workers are more productive. Increased wages lead to more disposable income available for housing purchases.

4.2.6. Population

The population of Sweden is gathered through SCB and is presented on a quarterly basis. The population level is indicative of the aggregate demand for housing. Generally, the population change is undramatic. Hence, planning and building of housing units to meet future demand should not be an issue. However, a shock to population will in turn result in a demand shock for housing. For the time frame of the study, two periods of high migration have occurred.

4.2.7. Unemployment Rate

The unemployment rate data has been gathered through the OECD. It was presented as seasonally adjusted. The unemployment level is indicative of the general state of the economy. If the economy is in a poor state, institutions are less willing to finance home purchases as the risk of defaults is increased. This results in lower amounts of buyers as the financing opportunities are constricted. Additionally, being unemployed or concerned about unemployment would reduce the willingness to purchase new housing.

5. Method

The analysed data is in the form of a time series, the model was specified to accommodate for this. Standard linear regression usually fails when analysing time series data of economic variables. Additionally, economic variables are often cointegrated, meaning they move in the same general direction over time, and only momentarily diverts from its long-term equilibrium. The standard approach to modelling time series includes regressing the first difference of the non-stationary variables. Using the cointegration method prevents loss of information when analysing I(1) variables over using differencing. The vector error correction model (VECM) estimates the long-run and short-run impact matrix. Cointegrating relationships are of interest since they define causality between two non-stationary variables. By using the VECM model, we gain the most insight into how interest changes affect housing prices. This framework is widely used within academia as there exists a cointegrating relationship between housing prices and macroeconomic variables. The methodology of cointegration is based on the work of Engle & Granger (1987) and Johansen (1991). For this thesis, inspiration for applying cointegration analysis on housing were drawn from the work of McGibany & Nourzad (2010) and Melinder & Melnikova (2016).

The augmented Dickey-Fuller test for stationarity was conducted first as the following techniques are based on the assumptions of this test. If variables pass the tests for stationarity, the Engle-Granger test and the Johansen trace and eigenvalue approaches for cointegration was utilized to evaluate if variables are cointegrated and at which rank. If cointegration was found, the vector error correction model was used to measure the long-run relationship and the adjustments of the variables at the first difference order.

5.1. Time Series Data

Time series data is common in the field of economics. The term “time series” is coined from the fact that the data is collected over time, usually in a set interval of months, quarters or years. All variables used in the model of this paper were defined as time series with the frequency of quarters.

The standard linear regression modelling of economic time series data can be problematic. For example, seasonal and trend components could lead to faulty conclusions regarding coefficient and significance of the variable (Gujarati, 2009). The previous values of the series have predictive power for the next observation. To combat this, the use of autoregressive models must be used.

A time series autoregressive model is defined as:

$$Y_t = \beta_0 + \beta_1 + \beta_2 t + \beta_3 Y_{t-1} + u_t$$

The error term, u_t, is a white noise term and t is time measured continuously. It's called AR(1)-model as Y_t is dependent on previous values of Y_t (Gujarati, 2009).

For multivariate models of time series data, vector autoregression (VAR) are used to capture the interdependencies of the variables. The VAR model builds on the AR(1) model but allows for multiple variables. It utilises the same principles but through a matrix form beyond the scope of this thesis (Gujarati, 2009). The VAR model is the basis of the VECM model, introduced in 5.7.

5.2. Stationary Requirement

Variables can either be stationary or non-stationary. A non-stationary variable contains a trend, a random walk component or both simultaneously. The traditional OLS-method of regression modelling requires variables to be stationary. By including a non-stationary variable in the model, the output statistics can be misguiding and lead to faulty conclusions. If several variables are non-stationary with a trend component the t-statistic and R^2 values will be inflated (Gujarati, 2009).

5.3. Augmented Dickey-Fuller Unit Root Test

A stationary series is one with a constant mean and variance for each given lag. To test for non-stationary variables, the augmented Dickey-Fuller test for unit root has been used. It allows for lagged values of the dependent variable to control for autocorrelation (Asteriou, 2015). Tables of lag selection is found under 9.1, in the appendix section. Prior to testing, we examine the graphical representation of the data to determine if a trend component must be included in the Augmented Dickey-fuller test. To use the series in a VECM model, it has to be a process integrated of order one with a unit root, I(1) (Johansen, 1995).

Unit root test:

$$\Delta y_t = \beta_0 + \varphi^* y_{t-1} + \sum_{i=1}^{p-1} \varphi_i \Delta y_{t-i} + u_t$$

By looking at the graphical representation of the data, a decision to include a trend component or not was made. If found, the Augmented Dickey-fuller test with a trend component was used. Secondly, a test of unit root was conducted on the first difference of the variable. If the null of unit root was rejected at the significance level at $P < 0.05$, we conclude that the variable is stationary at the first difference, I(1).

5.4. Lag Selection

The process of lag selection is important for the augmented Dickey-fuller test and the VECM model, which will be introduced in 5.7. The appropriate lag length is a must for the model to properly estimate the parameters and standard errors. Too few lags will lead to problems of autocorrelation. Too many lags will reduce the power of the test (Asteriou, 2015).

There are several methods of lag selection. Koehler and Murphree (1988) showed that SBIC is the most reliable while studying macroeconomic data. Therefore, the SBIC has determined the lag selection.

5.5. Cointegration

When subjecting two time series to a unit root test, which yields a result of a stochastic trend present in both variables, it's possible that they share the same trend, i.e. a regression might not be spurious. The linear combination of the variables cancels out the trend in the two series. In this case, the variables are cointegrated (Gujarati, 2009).

Variables are considered to be cointegrated if they have a long-term equilibrium, a relationship which hinders a large drift apart in any direction. Take the example of a random walk in the woods; a boy with his dog and a girl both take a walk in the woods. They are unrelated, and you cannot tell anything about the girl's position by learning the position of the boy and the dog. The boy walks with his dog using a leash. Individually, the boy and the dog are both on a random walk. However, they cannot drift too far apart due to the leash. Hence, they have a relationship, and you can predict the position of the dog by learning the position of the boy. The boy and the dog are cointegrated.

5.5.1. The Johansen Technique

The Engle-Granger test is insufficient for multivariate models where more than one relationship of cointegration can exist. Johansen and Juselius (1990) suggested using the trace test and the maximum eigenvalue t-statistics when identifying the number of cointegrating variables. The test is conducted within Stata by using the command 'vecrank'. Hubrich et al. (2001) showed that the Johansen technique had better properties for cointegration testing than other methods. If evidence for ranks of cointegration was found, appropriate ranks were used to correctly specify the vector error correction model.

5.6. Error Correction Mechanism

If the variables are cointegrated, there is a long-term equilibrium-based relationship. Additionally, there may be a short-term disequilibrium. The error term from the following equation is the short-term disequilibrium:

$$u_t = y_t - \beta_0 - \beta_1 x_t - \beta_2 t$$

This error term describes the short-run behaviour of y in relation to its long-term value.

The error correction mechanism corrects for disequilibrium. The Granger representation theorem states that if Y and X are cointegrated, then the relationship between them can be expressed as an error correction mechanism (Gujarati, 2009).

Consider a model where the change housing prices depends on the change in interest rate and an equilibrium error term.

$$\Delta HP_t = \alpha_0 + \alpha_1 \Delta IR_t + \alpha_2 u_{t-1} + \varepsilon_t$$

Where HP is housing price, IR is interest rate, u_{t-1} is the equilibrium error term of the previous period and ε_t is a white noise error term. If the equilibrium error term is non-zero, the model is not in equilibrium. Most of the time, the variables won't be in perfect equilibrium but instead move around their mutual long-term path. The coefficient α_2 is expected to be negative, as the variables should return to equilibrium. If the equilibrium error term is positive, it means that the housing price is too high to be in equilibrium with the interest rate. To return to equilibrium, the housing price will fall until $HP_t = \alpha_0 + \alpha_1 IR_t$ (Gujarati, 2009).

5.7. Vector Error Correction model

The VECM is based on the vector autoregressive model (VAR) which allows for relaxation of assumptions. The VAR model uses the lagged values of itself and by all other variables. It also implements $n \times n$ matrices of the parameters and a vector error term. The VAR model is transformed into the VECM model by differencing the cointegrated relationship. We don't have to meet assumptions of endogeneity or exogeneity of the explanatory variables using the VECM model (Gujarati, 2009).

Using the previous variables of the error term mechanism model:

$$\Delta HP_t = \gamma_0 + \gamma_1(HP_{t-1} - \beta_0 - \beta_1 IR_{t-1}) + \gamma_2 \Delta IR_t + v_t$$

Where the lagged variable of housing prices (HP_{t-1}) and interest rate (IR_{t-1}) is used as explanatory variables. The v_t is a disturbance of the equilibrium that leads to transitionary deviations. The γ_1 measures the speed of which the variables return to their equilibrium path.

The model can be generalized as follows, according to Engle and Ganger (1987):

'A vector of time series HP_t has an error correction representation if it can be expressed as:

$$A(L)(1 - L)HP_t = -\gamma z_{t-1} + v_t$$

Where v_t is a stationary multivariate disturbance, with $A(0) = I, A(1)$ has all elements finite $z_t = \acute{\alpha}\, HP_t$ and $\gamma \neq 0$.'

Using the previous example, the following equation is estimated by least squares (Granger, 1987):

$$\Delta HP_t = \gamma_0 + \gamma_1 \hat{u}_{t-1} + \gamma_2 \Delta IR_t + v_t$$

The vector error correction model was specified as follows:

$$\Delta HP_t = \beta_0 + \sum_{i=1}^{n} \varphi_{11} \Delta HP_{t-1} + \sum_{i=1}^{n} \varphi_{12} \Delta X_{t-1} + \alpha_0 E_{t-1} + \varepsilon_t$$

Where HP is the price of housing. The X is a vector which computes the independent variables mortgage rate, consumer price index, finished housing units and real GDP. E is the error correction-term and ε is a random error-term.

5.8. Johansen Normalization

The coefficients signs of the VECM model are reversed due to the Johansen normalization process (Johansen, 1995). To interpret the relationship of the variables, the signs was flipped. If the coefficient was presented as a negative in the table, it will be positive when presenting the equation describing the relationship of the variables.

6. Results

In this section, the results of the applied econometric methods are presented.

6.1. Unit Root Test

The augmented Dickey fuller test is used on the natural logarithms of the variables, if not otherwise stated. All variables but population and unemployment rate met the requirements of stationary at the first difference. As they failed, they were not included in the model for housing prices.

6.1.1. Housing Prices

Housing prices display a convincing trend for national, Stockholm and Gothenburg when looking at the graphical representation of the data. Hence, a trend component was included. As displayed in Table 2, Table 3 and Table 4, the test yields a statistic smaller than our critical value. Hence, at the significance level at P <0.05, we could not reject the null hypothesis of unit root for housing prices in any region at I(0).

The test on the first difference yields a statistic larger than our critical value. The null hypothesis of unit root is rejected at the significance level at P <0.05. The conclusion was that housing prices in all regions are stationary at the first difference, I(1).

Table 2. *Results from unit root test of national housing prices*

	Test Statistic	5% Critical Value	SBIC	Number of lags
ADF *(With trend)*	-1.584	-3.461	-5.545	6
ADF $\Delta_1\ H_{Nat\ t}$	-3.440*	-2.899	-5.548	5

* significant at the 5% level

Table 3. *Results from unit root test of Stockholm house prices*

	Test Statistic	5% Critical Value	SBIC	Number of lags
ADF *(With trend)*	-2.742	-3.459	-4.959	4
ADF $\Delta_1\ H_{Sto\ t}$	-2.899*	-2.897	-4.947	3

* significant at the 5% level

Table 4. *Results from unit root test of Gothenburg house prices*

	Test Statistic	5% Critical Value	SBIC	Number of lags
ADF *(With trend)*	-1.277	-3.456	-4.809	1
ADF $\Delta_1\ H_{Got\ t}$	-9.073*	-2.895	-4.768	0

* significant at the 5% level

6.1.2. Household Mortgage Rate

The household mortgage rate displayed no obvious trend. As shown in Table 5, we failed to reject the null hypothesis of a unit root process for mortgage rates. The test on the first difference of mortgage rates indicated that the differenced series was stationary, I(1).

Table 5. *Results from unit root test of mortgages rates*

	Test Statistic	5% Critical Value	SBIC	Number of lags
ADF *(No trend)*	-1.596	-2.896	-2.169	2
ADF $\Delta_1\ M_t$	-4.535*	-2.896	-2.172	2

* significant at the 5% level

6.1.3. Consumer Price Index

Consumer price index showed a clear indication of a linear trend over time. As shown by Table 6, we failed to reject the null hypotheses of a unit root at I(0). The test on the first difference of the series yielded a higher test statistic than the critical value at the significance level at $P < 0.05$. The consumer price index was stationary after first difference, implying a I(1) process.

Table 6. *Results from unit root test of consumer price index*

	Test Statistic	5% Critical Value	SBIC	Number of lags
ADF *(With trend)*	-2.953	-3.461	-7.672	6
ADF $\Delta_1\ C_t$	-3.134*	-2.899	-7.817	5

* significant at the 5% level

6.1.4. Population

The population showed a clear trend. Displayed at Table 7, we failed to reject the null hypothesis of a unit root at the significance level at $P < 0.05$. When conducting the test on the first difference of the data, we once again failed to reject the null of a unit root. Hence, we were unable to include the population as a variable in the VECM model, as it was non-stationary after the first difference.

Table 7. *Results from unit root test of population*

	Test Statistic	5% Critical Value	SBIC	Number of lags
ADF *(With trend)*	-1.927	-3.462	-13.038	7
ADF $\Delta_1 P_t$	-1.536	-2.900	-13.074	6

* significant at the 5% level

6.1.5. Finished Housing Units

Finished housing units displayed a trend. As displayed in Table 8, we failed to reject the null hypothesis of a unit root at the significance level at $P < 0.05$. When conducting the test on the first difference of the series, the test statistic yielded a higher value than the critical value. We could hence reject the null. The finished housing units were stationary at first difference.

Table 8. *Results from unit root test of finished units*

	Test Statistic	5% Critical Value	SBIC	Number of lags
ADF *(With trend)*	-2.427	-3.460	-1.816	5
ADF $\Delta_1 F_t$	-3.056*	-2.901	-1.896	8

* significant at the 5% level

6.1.6. Unemployment Rate

Unemployment did not display a trend. As displayed in Table 9, we rejected the null hypothesis of a unit root at the significance level at P <0.05. Unemployment were stationary, implying a process integrated of order zero with a unit root. Therefore, we were unable to include unemployment as a variable in the model.

Table 9. *Results from unit root test of unemployment*

	Test Statistic	5% Critical Value	SBIC	Number of lags
ADF *(No trend)*	-3.853*	-2.897	-3.691	4
ADF Δ_1 F_t	-3.357*	-2.896	-3.626	2

* significant at the 5% level

6.1.7. Real Gross Domestic Product

Real GDP displayed a trend. As displayed in Table 10, we failed to reject the null hypothesis of a unit root at the significance level at *P* <0.05. When conducting the test on the first difference of the series, the test statistic yielded a higher value than the critical value. We could hence reject the null. The real GDP was stationary at first difference, implying a I (1) process.

Table 10. *Results from unit root test of real GDP*

	Test Statistic	5% Critical Value	SBIC	Number of lags
ADF *(With trend)*	-2.116	-3.461	-6.124	6
ADF Δ_1 F_t	-4.513*	-2.899	-6.111	5

* significant at the 5% level

6.2. Cointegration of national Housing Prices

The Johansen test indicated that we had two ranks of cointegration. The results of the Johansen tests are presented in appendix 9.3. The VECM model for national housing prices will use two cointegration equations. For a model using two cointegrating equations, one variable must be omitted. We chose to omit real GDP. While all variables chosen for the model were deemed to have a predictive power for housing prices, real GDP were the least significant in our opinion.

The chosen lag for the VECM model of national housing prices is three. The results of the suggested lag test are presented in appendix 9.1.1.

6.2.1. Long-run Cointegration Equation

Table 11. *Cointegration equation for CE1, National Housing prices*

Beta	Coef.	Std. Err.	P>|z|	95% Conf. Interval	
Housing prices	1				
Mortgage rate	0.303*	.077	0.000	0.153	0.453
CPI	-3.674*	.541	0.000	-4.735	-2.614
Finished units	0.089	.085	0.294	-0.077	0.255
Real GDP	Omitted				
Constant	10.863				

** significant at the 5% level*

Estimating the VECM model with three lags and an unrestricted constant yields the following relationship:

$$Housing\ prices_t = -0.303 \times Mortgage\ rate_t + 3.674 \times CPI_t - 10.863 + u_t$$

As the mortgage rate increases, the model estimates lower housing prices. The variables are natural logarithms. Therefore, if mortgage rates were to rise by 10 percent, the model predicts a 3.03 percent decline in housing prices. The same coefficients apply when the interest rate declines.

The second cointegration equation, which explains the relationship of the variables on real GDP is presented in appendix 9.2.

6.2.2. Short-run Cointegration Equation 1

Table 12. *Short-run error correction equation 1*

Equation	Coef.	Std. Err.	P>|z|	95% Conf. Interval	
Housing prices	0.033	0.030	0.270	-0.257	0.092
Mortgage rate	0.424*	0.202	0.036	0.029	0.819
CPI	0.043*	0.011	0.000	0.019	0.066
Finished units	-0.496	0.319	0.120	-1.122	0.129
Real GDP	-0.010	0.245	0.687	-0.058	0.038

** significant at the 5% level*

The results of the short-term relationship equations suggest that short-term adjustments to equilibrium happens through the interest rate and inflation. This means that when the system lies below its equilibrium, interest rates and inflation will adjust downwards until equilibrium is reached. The speed of adjustment is the quickest through the interest rate. It corrects by a rate of 42 percent per quarter, implying that the system is generally back in equilibrium in three quarters.

6.3. Cointegration of Stockholm Housing Prices

The Johansen test indicates one rank of cointegration. The results of the test are presented in appendix 9.4. Compared to national housing, we had one less cointegration relationship using the same variables.

The VECM model uses three lags, as suggested by SIBC. The results of the suggested lags are presented in appendix 9.1.2.

6.3.1. Long-run Cointegration Equation

Table 13. *Cointegration equation for Stockholm Housing Prices*

Beta	Coefficient	Std. Err.	P>|z|	95% Conf. Interval	
Housing prices	1				
Mortgage rate	0.634*	0.093	0.000	0.452	0.818
CPI	-0.608	0.876	0.488	-2.325	1.110
Finished units	0.349*	0.113	0.002	0.127	0.570
Real GDP	-2.014 *	0.572	0.000	-3.136	-0.892
Constant	3.335				

** significant at the 5% level*

The consumer price index is not significantly different from zero. For Stockholm, it does not have a relationship with housing prices.

Estimating the VECM model with three lags and an unrestricted constant yields the following relationship:

$$Housing\ prices\ Stockholm_t = -0.634 \times Mortgage\ rate_t - 0.349 \times Finished\ units_t + 2.014 \times Real\ GDP_t - 3.335 + u_t$$

The results imply that there exists a significant long-run relationship between Housing prices, Mortgage rate, finished units and Real GDP. As the mortgage rate increases, the model estimates lower housing prices. If mortgage rates were to rise by 10 percent, the model predicts a 6.34 percent decline of housing prices in Stockholm.

6.3.2. Short-run Cointegration Equation

Table 14. *Short-term equation for Stockholm Housing Prices*

Equation	Coefficient	Std. Err.	P>|z|	95% Conf. Interval	
Housing prices	-.0418*	.0178	0.019	-.0768	-.0069
Mortgage rate	-.2583*	.0781	0.001	-.4116	-.1051
CPI	.0017	.0049	0.736	-.0080	.0113
Finished units	.0263	.1254	0.834	-.2196	.2721
Real GDP	-.0400*	.0098	0.000	-.0593	-.0207

** significant at the 5% level*

The negative coefficient speed of adjustment for housing prices in Stockholm indicated that when it’s above its equilibrium, housing prices will decline as the system adjust back into equilibrium. When there are deviations from the systems equilibrium, the housing price, interest rate and real GDP will adjust until equilibrium is reached. The quickest adjustment happens through the interest rate which will correct by a speed of 25 percent per quarter. This means that equilibrium is generally reached within a year. The direction of change for the mortgage rate is different from the national level and Gothenburg, which both have a positive sign.

6.4. Cointegration of Gothenburg housing prices

The Johansen test for cointegration found one rank of cointegration. The results of the test are presented in appendix

6.4.1. Long-run cointegration equation

Table 15. *Cointegration equation for Gothenburg Housing Prices*

Beta	Coefficient	Std. Err.	P>|z|	95% Conf. Interval	
Housing prices Gothenburg	1				
Mortgage rate	0.098*	.023	0.000	.054	.142
CPI	-1.539*	.202	0.000	-1.934	-1.143
Finished units	-0.027	.027	0.283	-.078	.023
Real GDP	-2.664*	.133	0.000	-2.92	-2.405
Constant	14.734				

** significant at the 5% level*

Estimating the VECM model with three lags and an unrestricted constant yields the following relationship:

$$Housing\ prices\ Gothenburg_t = -0.098 \times Mortgage\ rate_t + 1.534 \times CPI_t + 2.664 \times Real\ GDP_t - 14.734 + u_t$$

As the mortgage rate increase, the model estimates lower housing prices. If mortgage rates were to rise by 10 percent, the model predicts a 0.98 percent decline of housing prices in Gothenburg.

6.4.2. Short-term cointegration equation

Table 16.

Equation	Coefficient	Std. Err.	P>|z|	95% Conf. Interval	
Housing prices	-.1026	.0767	0.181	-.2530	.0477
Mortgage rate	.6042*	.2859	0.035	.0439	1.165
CPI	.0015	.0174	0.930	-.0326	.0357
Finished units	-1.554*	.3681	0.000	-2.275	-.8324
Real GDP	.0985*	.0338	0.004	.0322	.1648

** significant at the 5% level*

When there are deviations from the systems equilibrium, mortgage rate, finished units and real GDP will adjust until equilibrium is reached. The quickest adjustment happens through the finished units. The coefficient for CPI and Housing Prices are not significant. Which indicates that the variables are exogenous. It implies that deviations are not corrected by changes in housing prices or CPI in the short run.

7. Analysis

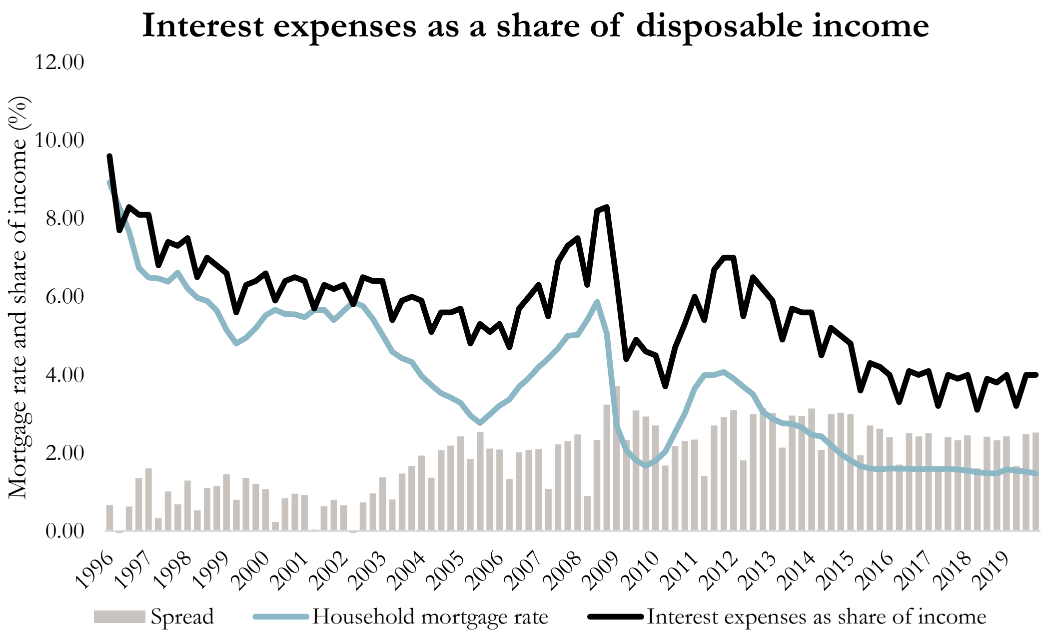
7.1. National Housing

First, GDP were omitted on the national level due to two ranks of cointegration. Secondly, finished units were not statistically significant, leaving mortgage rates and CPI as the only significant variables on the national level. A ten-percentage change in mortgage rates would yield an opposite 3.03% change in housing prices. Meanwhile, a ten-percentage change in CPI would yield a change of 36.74% of housing prices in the same direction of change. While the coefficient is higher for CPI, the rate of change during is a short period is generally lower than for interest rates. The Riksbank generally adjust the repo rate by 25 basis points, and in some cases 50 basis points. The latest mortgage rate data point is at 1.48 percentage. A repo hike of 25 basis points, if completely transferred to mortgage rates, would equal a 16.9 percent increase in mortgage rates. This would result in a decline of national housing prices by 5.1 percent. Mortgage lenders requires a minimum equity stake of 15 percent to grant the housing loan for buyers. In the case of an interest rate hike of 75 basis points, the results of this study suggest that an equity stake of 15 percent would be wiped out. The implications of this is outside the scope of this thesis but could be considered severe. The wealth effect of changes in house prices has a significant and large positive correlation with consumer spending, as observed by Case et al. (2005).

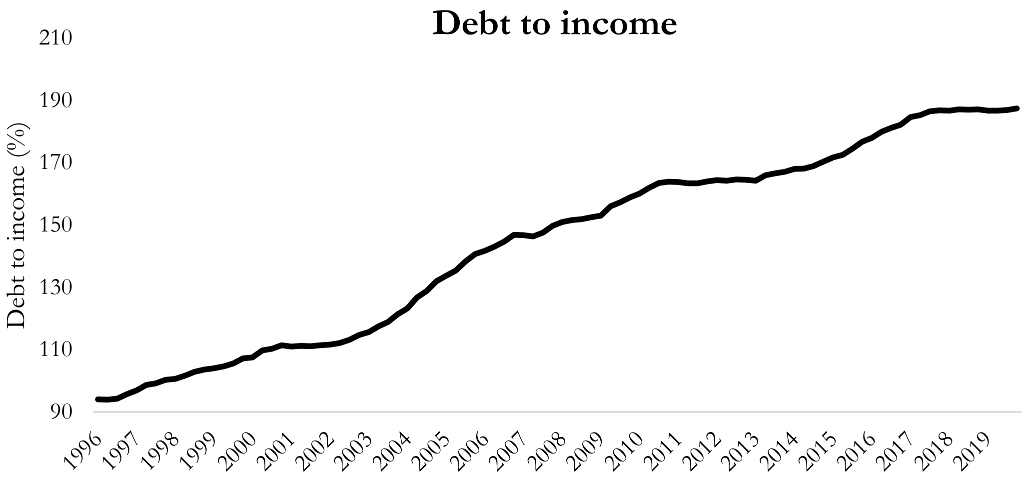
The results of this study suggest that mortgage rates are less inelastic than observed in previous studies. McGibany & Nourzad (2010) found that the elasticity between 1963 and 1997 in the US were -0.0789, and previous studies found it to be –0.069 and –0.086 in the UK and Ireland. Although a large difference, the time periods are vastly different: McGibany & Nourzad’s paper looked at data during a time of high interest rates and inflation. Generally higher than levels observed in this thesis. The results of this thesis shine a light on the elasticity of interest rates and housing prices during a period of low interest rates and inflation.

A change in CPI has a large effect on housing prices. Large shifts in CPI have been rare during the analysed data set. Six quarters of out the 92 observed show a change of more than 3% year-over-year. The result is in line with previous studies made by Harris and Wong and Hui & Seabrooke (2003). They found that inflation is the best predictor of housing prices as housing 1) protects against inflation, 2) becomes relatively cheaper compared to renting, 3) inflation reduces the value of the mortgage loan in real terms, and 4) drives expectations of further housing price appreciation.

Housing prices has three times the sensitivity of general price changes. The high coefficient of the consumer price index could in part be due to the relative cost of general goods compared to declining housing costs, caused by the interest rate. Over the observed time period, interest rates and the share of income spent on interest payments has both declined.



By graphical analysis, we conclude that they correlate, but that the spread has increased over time. The presented data were gathered from SCB (2020). The interest expenses as a share of income has decreased to a lesser degree than the mortgage rate. This suggests that households are willing to take on larger loans if the costs of doing so is in line with previous ratios of income. A consistent ratio of interest expenses enables the consumer to consume the same basket of goods over time. This is further supported by the debt to income level. The data for debt to income is gathered from SCB (2020).The ratio of interest expenses has decreased while the dept to income level has doubled during the period.



In the short-run, mortgage rates and inflation are the significant variables impacting adjustments to equilibrium. The mortgage rate adjusts at a high velocity when a shock to the system occurs. It signals that the mortgage lenders are quick to adjust their lending rates. Additionally, it signals that the central bank has acted quickly in adjusting the repo rate as a response to shocks. As inflation responds to a disequilibrium in housing markets in the same direction, it suggests that changes in housing prices determines short term inflation. This is supported by previous research by Nguyen and Wang (2010). They found evidence that the growth of the housing market leads to higher inflation in the short-run.

7.2. Stockholm Housing

In Stockholm, the model found three variables to be statistically significant: mortgage rates, finished units and real GDP. Changes in real GDP results in the largest changes in housing prices according to the model. A ten percent change in real GDP results in a 20.14% change in housing prices. The rationale behind this is intuitive: as people increase their income, they can afford to pay more for housing.

Mortgage rates impacts housing prices in Stockholm twice as much as the country average, at 6.34% per 10%. Again, the rationale behind this is intuitive: the price per sqm in Stockholm is 46,017kr and for the country 26,482kr (Mäklarstatistik, 2020). This is only partially offset by higher income in Stockholm. The average income in

Sweden is 308,716kr compared to 359,940kr for Stockholm, a 17% difference (Hansson, 2020). This means that people in the Stockholm area are likely more indebted than the rest of the nation, meaning that an interest change affects them to a larger extent than residents in other parts of the nation. Some relative loan differences could be mitigated by residents of Stockholm living in smaller housing. There is no statistics on house sizes for the regions. The elasticity of –0.634 between mortgage and housing prices is close to the -0.7 that Carjias & Ertl found in their 2017 study.

Finished units did not have any statistical effect on housing prices on a national level. In Stockholm however, finished units affects the housing price by –3.49 percent if the number of finished units increase by 10 percent. Housing supply was one of the three factors that were found to be important for housing prices in Asal's 2018 study. One factor that is characteristic for Stockholm is the amount of condominiums compared to the national level. Therefor finished housing may have a percentual higher impact in Stockholm.

CPI did not have any significant impact on housing prices in Stockholm. This result is surprising as it was the most important predictor for housing prices on a national level. However, the result is in line with Asal's study, which did not find inflation to be important.

Comparing Stockholm housing prices to the national level is not perfect. Small housing, as observed in this study, and condominiums are not perfect substitutes. Most condominiums are in larger cities. As a result, the price level of major cities would have a larger weight in the condominium price index. By using condos, the analysis would have been skewed as the economic conditions of major cities would have had a significantly larger weight than the rest of the country. As a result of this, the results derived from small housing might not be applicable to condominiums located in Stockholm, which is most of the housing in the region.

The short terms adjustments to equilibrium happens through the housing price, mortgage rate and real GDP. When housing prices are above equilibrium, the housing price will decline over the coming periods, back into equilibrium. It will do so at the low velocity of 4 percent per quarter. The sign of the coefficient for mortgage rate is reversed to that of the nation and Gothenburg for the short-term adjustment. As the regions share the same mortgage rate data, this suggests that shocks to housing prices are not synchronized across the nation.

7.3. Gothenburg Housing

In Gothenburg, the model found three variables to be statistically significant: mortgage rate, CPI and real GDP. Finished units did not have any statistical significance on housing prices in Gothenburg.

The effect of mortgage rate changes on housing prices is less than for Stockholm. The mortgage rate effect in Gothenburg were more inelastic than for the country at –0.098, roughly 1/3 of the national average. This is somewhat surprising as the two cities are two of the major cities in Sweden. The expectation was similar results. The result is however close to what McGibany & Nourzad found in the US at –0.0789.

Inflation were in line with expectations, a 10 percent change in CPI would yield a 15.39 percent same direction change in housing prices. The rationale for this result expressed in the analysis of Stockholm housing applies for Gothenburg as well.

Real GDP has a large effect on housing prices in Gothenburg. A 10 percent change in real GDP results in a 26.6 change in housing prices in the same direction. The magnitude of response is slightly higher than that of Stockholm.

In the short run, disequilibrium is corrected by the mortgage rate and finished units. Finished units has not been significant in the other regions. One would expect that finished units were mostly significant in the long term. Building a house has a length lead time from start to finish. The velocity if -1.539 indicates that the response in finished units overshoots the shock of disequilibrium in the housing market. It corrects for 154 percent of the disequilibrium in one quarter. It suggests that if housing prices are under the equilibrium level, finished units will significantly decrease. In the long-term, the economic rationale is that this decrease of building would increase the housing prices and hence return to equilibrium.

7.4. Suggestion for further research

In this analysis, houses were used as a proxy for the whole market. This has likely led to a skewness in the results because most houses are relatively larger than an average condo, situated in a suburban areas or small town and purchased by the middle-aged population. Any future research would preferably analyse at the market for condominiums. It would give further insight into the broad market for housing and allow for comparisons of the different dwelling types.

To reach deeper understanding of the housing market, researchers should analyse a wider range of variables. The variables used in this paper have significant power in explaining changes in housing prices. However, it does not explain all the variability. Ways to integrate population data, unemployment, economic sentiment and more without introducing problems with model specification would be valuable.

Finished units would benefit of better data as finished units for the whole nation has been used in not only the national overview, but for Stockholm and Gothenburg as well. Even though housing in different regions are complements, they are not perfect compliments as someone living in Stockholm may not want to move to Gothenburg (or vice versa).

The goal with this thesis were to investigate the role mortgage rates have on housing prices to find out wheatear there is a real risk of wiping out the equity of homeowners where interest rates to increase. As presented above, there is a significant risk. Future research should investigate the effect an equity wipe-out would have on the economy and housing market.

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9. Appendices

9.1. Lag Selection

9.1.1. National Housing prices

Table 17. *Suggested lag National model*

Selection	LR	FPE	AIC	HQIC	SBIC
Lag	8	6	6	3	3

9.1.2. Stockholm Housing Prices

Table 18. *Suggested lag Stockholm model*

Selection	LR	FPE	AIC	HQIC	SBIC
Lag	8	6	8	3	3

9.1.3. Gothenburg Housing Prices

Table 19. *Suggested lag Gothenburg model*

Selection	LR	FPE	AIC	HQIC	SBIC
Lag	8	5	7	4	3

9.2. Real GDP, cointegrating equation 2.

Table 20. *Cointegration equation for CE2, Real GDP*

Beta	**Coef.**	**Std. Err.**	**P>|z|**	**95% Conf. Interval**	
Housing prices	Omitted				
Mortgage rate	.181*	.055	0.001	.074	.288
CPI	-.289	.385	0.453	-1.043	.466
Finished units	.043	.060	0.480	-.076	.161
Real GDP	1				
Constant	-4.081				

* significant at the 5% level

The formula is a linear combination of four variables, which is stationary when combined. The coefficient signs are reversed due to the Johansen normalization process. To make it intuitive, we rewrite the formula:

$$Real\ GDP_t = -0.181 \times Mortgage\ rate_t + 0.289 \times CPI_t - 0.043 \times Finished\ units_t + 4.081 + u_t$$

The mortgage rate is the only significant variable for determining real GDP. If the mortgage rate were to increase by 10 percent, real GDP would decline by 1.81 percent. This is the long-term relationship of interest rate changes on the real GDP.

9.3. Johansen test of cointegration National Housing Prices

As displayed in Table 21, the Johansen test indicates that we have more than one rank of cointegration at the 5 percent significance level. We fail to reject the null of more than two cointegrating relationships. Hence, we use two ranks of cointegration in the model.

Table 21. *Test of cointegration between national housing prices, Household Mortgage rates, Consumer price index, finished housing units and real GDP, 3 lags.*

Rank	LL	Eigen-value	Trace Statistic	5% Critical Value
0	1256.81		90.05*	68.52
1	1275.15	0.335	53.38*	47.21
2	1289.41	0.272	24.86	29.68
3	1296.87	0.153	9.94	15.41

* significant at the 5% level

9.4. Johansen test for cointegration Stockholm

As displayed in Table 22, the Johansen test indicates that we have more than zero ranks of cointegration at the 5 percent significance level. We cannot conclude that we have more than one rank of cointegration.

Table 22. *Test of cointegration between Stockholm housing prices, Household Mortgage rates, Consumer price index, finished housing units and real GDP, 3 lags.*

Rank	LL	Eigen-value	Trace Statistic	5% Critical Value
0	1157.5905		69.2374*	68.52
1	1171.3976	0.25690	41.6232	47.21
2	1181.7199	0.19907	20.9787	29.68
3	1187.2606	0.11233	9.8972	15.41

* significant at the 5% level

9.5. Johansen test for cointegration Gothenburg

As displayed in Table 23, the Johansen test indicates that we have more than zero ranks of cointegration at the 5 percent significance level. We fail to reject the null of more than one rank of cointegration.

Table 23.

Rank	LL	Eigen-value	Trace Statistic	5% Critical Value
0	1162.3436		88.6636*	68.52
1	1184.9503	0.38826	43.4503	47.21
2	1194.2551	0.18313	24.8406	29.68
3	1200.9396	0.13525	11.4716	15.41

* significant at the 5% level