UNIVERSITY OF GOTHENBURG

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A Valuation of the Swedish Real Estate Market

An Autoregressive Distributed Lagged Model Approach

Alexander Winberg

Supervisor: Prof. Aico Van Vuuren

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Abstract

I study the valuation of the Swedish real estate market by using an error correction model (ECM). I estimate an ECM by using an autoregressive distributed lag model (ARDL). By choosing an ARDL model, this paper overcomes previous critic; that all variables are assumed to be integrated of the same order. This model displays similar results as previous research, even though it estimates variables of different orders. Further, I find that the coefficients in the model are unstable, indicating that the effect from the fundamental factors to real estate prices changes over time. At last, I do find a small overvaluation at 0.96 percent in the Swedish real estate market.

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1. INTRODUCTION

Since 1994, real prices for real estates have increased with over 180% without any significant drops. In many countries real estate prices dropped during 2007-2008, although in Sweden the prices continued to increase. This raises the question if the Swedish real estate market is correctly valued. A correct valuation of properties is important for every household, since most of the Swedish citizens owns their own resident (Sköld, 2014). Furthermore, the property is often the most valuable asset for a household and a decrease in this asset would harm the household's economy significantly. This leads to that the families' ability to pay their mortgage and their ability to consume which later could transmit to the whole Swedish economy. Therefore, this is of interest for policymakers. The research question of this paper is:

Is the Swedish real estate market overvalued?

In addition to answer the research question, this paper will contribute to the existing literature by using an autoregressive distributed lagged model (ARDL). Previous papers have assumed that all variables are integrated of the same order while the ARDL approach can implement variables of different orders. Further, this paper has studied the stability of the coefficients. Critic against previous research is that the effect from the fundamental factors on real estate prices could be affected by periods where the market is in disequilibrium. By estimating the stability of the coefficients and by dividing the sample in to shorter time periods, I tried to adjust this critic.

Research regarding the Swedish real estate market has been done. Claussen (2012) found that disposable income, financial wealth and interest rate are fundamental factors explaining real estate prices. He also concludes that there was no overvaluation in 2011. Another more recent study is made by Turk (2015). He also found that disposable income, financial wealth and interest rate are fundamental factors. In addition, he found an effect in population, a variable that Claussen (2012) did not include due to data unavailability. Another difference between the studies is that Turk (2015) concluded that the real estate market was overvalued in the beginning of 2015.

In line with previous research, I will estimate a model using disposable income, interest rate and financial wealth. As for Claussen (2012), I have to exclude population due to unavailable data. It is of major interest to estimate a model similar to Claussen's (2012) and Turk's (2015) since the Swedish central bank where served the work from Claussen (2012) and IMF where served the results from Turk (2015). By using a similar approach, I got an insight in the tools that the policymakers consider.

This paper used time series data from Sweden, covering the period from the first quarter in 1986 till the fourth quarter in 2016. I analyze the effect of income, financial wealth and interest rate on real estate prices. The results from this paper are that there is a small overvaluation of 0.96 percent in the Swedish real estate market and that the autoregressive distributed lagged model displays similar result as previous methods. I find that financial wealth is insignificant and seems to not belong in the real estate model. The results also indicate that the coefficients are unstable over time, meaning that fundamental factors effect on house prices differ over time.

The rest of this paper is structured as follows: In Section 2 the literature review is presented. Section 3 contains the theoretical framework. An economic background to what drives real estate prices and the concept of bubble will be presented here among with some background characteristic of the Swedish real estate market. Further in Section 4, data and descriptive statistic will be presented and the dataset will be presented together with some descriptive statistics regarding the data. Section 5 is empirical strategy. The methods that are used in the paper will be presented here. In Section 6, the result will be presented and in section 7 the analysis will be presented. Finally, in Section 8, the conclusion is presented.

2. LITTERATEUR REVIEW

Literature related to real estate markets has been growing rapidly for the last years and there are several different methods to examine this question. The error correction model has a long tradition within real estate economics and is the leading approach in this area (Claussen, 2012). An error correction model tries to estimate a long-run relationship between variables. By doing this, one can study if variables tend to move together during long time periods. The model uses lagged values of the dependent variable to correct for errors, which explains the name ‘error correction model’.

Claussen (2012) and Turk (2015) uses this method when they study the Swedish real estate market. Claussen (2012) found that disposable income, interest rate and financial wealth were fundamental factors which could explain the real estate prices. His paper presents a result of no significant overvaluation in 2011. Turk (2015) also found that the same variables could describe the long-run fundamental value. In addition, he found an effect on net migration which Claussen (2012) did not add due to unavailable data. Turk (2015) found signs of overvaluation in the second quarter of 2015. The result was that prices deviate about 5.5 percent from their long-run equilibrium. With consideration to the historic low interest rate, he found overvaluation of about 12 percent. Both papers found similar coefficients of the variables, which can be seen in Table 1. The coefficients measures elasticity between the fundamental factors and the real estate prices, meaning that they explain the percentage change in real estate prices when there is a percentage change in a fundamental factor. For example, Claussen (2012) found an income-elasticity of 1.3, meaning that a 1 percent increase in income will yield to a 1.3 percent increase in house prices. The elasticities are income elasticity, interest rate elasticity and financial wealth elasticity.

TABLE 1. FUNDAMENTAL FACTORS ELASTICITIES TO REAL ESTATE PRICES FROM PREVIOUS PAPER.

Variables	Claussen (2012)	Turk (2015)
Income	1.3	1.13
Interest rate	-0.06*	-0.04*
Financial Wealth	0.12	0.076
Constant	-17.04	4.161
Adjustment coefficient	-0.08	0.075

*Semi-elasticity

Critic against the error correction model is the high produced income elasticity which cannot be stable in the long-run (Flam, 2016). For example, Claussen (2012) found an income elasticity of 1.3, which means that a 1 percent increase in income yield a 1.3 percent increase in real estate prices. This relationship cannot hold in the long-run due to the fact that the prices will increase more than income and houses will no longer be affordable. According to Jacobsen & Naug (2005) it is usual to find an income elasticity around one when not adding housing stock and other supply factors in the model. This paper will not have the ability to address this issue due to unavailable data and we could expect an income elasticity around 1 in this paper as well. According to Davis et al (2011) the theoretical long-run income elasticity is one.

Another critic that both Claussen himself as well as Sørensen (2013) comments is the implementation of interest rate. In the model it is assumed that interest rate is non-stationary, which it is not in the very long-run according to both theory and empirical testing. However, during a short time period interest rate could be non-stationary. I will address this problem by using an ARDL model which can use variables integrated of different orders.

Further critic against the error correction model is that real estate prices changes slowly. This means that a bubble could be built during a long time period and the relationship found in the estimation is affected by this valuation. One way to correct this is according to IMF (2003) to estimate the coefficient using data from a period which is not part of a bubble, which I will try to do. I will also study if the magnitude of the coefficients is stable over the whole sample to address this problem.

3. THEORETICAL FRAMEWORK

3.1 WHAT DRIVES REAL ESTATE PRICES?

Factors driving real estate prices are often heavily debated. Different factors could affect prices in the short-run, but not have an effect in the long-run. One could also argue that different countries have different structures and laws regarding the real estate market and are affected by different components. According to classic economic theory, the real estate market could be explained by demand and supply. An equilibrium would arise when demand is equal to supply. In the simplest form, supply should be driven by number of houses and demand would be driven by population. With that said, one can extend the analyze and derive the factors that affect the demand and supply. Meen (2002) argues that in the long-run, real estate prices will move in line with construction cost. However, if real estate prices are found to trend and be non-stationary, this relationship do not hold and the economic factors behind the demand and supply needs to be further explored (Meen, 2002).

According to Meen (2002), the life-cycle model can explain which factors that affect real estate prices. I will use the work from Mean (2002) to determine which factors that should be included in the long-run model, explaining real estate prices. The life cycle model derive the marginal rate of substitution between consuming houses (u_h) and consuming other goods (u_c). This can be seen in Equation 1 where the essence is that consumer maximize consumption utility.

$$u_h / u_c = G(t) = \left[(1-\theta)i(t) - \pi + \delta - g^e / g(t)\right] \quad (1)$$

where

G(t) = real purchase price of house
θ = households marginal tax rate
i(t) = interest rate
δ = deprecation rate in households
π = inflation
(.) = time derivate
$g^e / g(t)$ = expected real capital gain
θ, δ, π are assumed to be time invariant

An assumption for the marginal rate of substitution is that the market is efficient. For the market to be efficient, Equation 2 also needs to hold. If this is not the case, an arbitrage opportunity exists in the market. Meen (2002) argues that the market is not always efficient by presenting evidence from US and UK.

$$G(t) = R(t) / \left[(1-\theta) i(t) - \pi + \delta - {g^e}/{g(t)} \right] \quad (2)$$

where

R(t)= real imputed rental price of housing services

Imputed rent describes the price that the current homeowner would be willing to pay to live in his house. This variable is a hypothetical value which could affect the analysis. Meen (2002) argues that Equation 1 contains a demand function for the real estate market. Further assuming from the life-cycle model; income, financial wealth and demographic factors will be on the demand side and real estate stock will be on the supply side. Considering this, one ends up with the demand function in Equation 3. The supply side is displayed in Equation 4.

$$g(t) = \alpha_1 + \alpha_2 (hh)_t + \alpha_3 (ry)_t + \alpha_4 (h)_t + \alpha_5 (w)_t + \alpha_6 (rr)_t + \varepsilon_{1t} \quad (3)$$

where

g(t)= real house prices
hh_t= number of households (population)
ry_t= households' disposable income
h_t= number of real estates
w_t= households' wealth
rr_t= real interest rate

$$h_t = \beta_1 + \beta_2 (g)_t + \beta_3 (cc)_t + \beta_4 (h)_{t-1} + \varepsilon_{2t} \quad (4)$$

where

cc_t= conctruction cost

Equation 3 and 4 can be compound into one equation and be rewritten as an inverted demand function (Turk, 2015). Real estate prices (p), can then be explained by a long-run equilibrium-equation which include real estate stock (h_t) and the demand factors X_t. This long-run model is presented in Equation 5. The error term is here assumed to be stationary.

$$p = \beta_0 + \beta_1 h_t + \beta_2 X_t + \varepsilon_t \quad (5)$$

The prices can therefore be said to be explained by the real estate stock h_t and the demand factors. Further, the variables are transformed into logs to display elasticities.

3.2 Valuation

Sørensen (2011) argues that one can value a market in three different ways:

- if the prices are above their long-term trend
- if they prices cannot be explain by the fundamental factors
- if one predicts prices to decrease in the future

This paper will use the second definition; when fundamental factors cannot justify the prices, there exists a miss-valuation. Stiglitz (1990) argues that the fundamental factors should explain the asset price. This is quoted from Stiglitz (1990):

"If the reason that the price is high today is only because investors believe that the selling price will be high tomorrow – when "fundamental" factors do not seem to justify such a price – then a bubble exist."

Case & Shiller (2004) also argues that fundamental factors should explain the prices for it to be a justified valuation in the market. The fundamental value in this paper will be defined as the value predicted by the error correction model. The values from the ECM will then be compared to the actual prices on the market. I will therefore, by assuming that the values from the ECM are the fundamental values, be able to compare actual values to fundamental values. This will serve as the valuation method later in this paper.

When the actual values differ from the fundamental values predicted by the error correction model, this paper will consider it as a miss-valuation in the market. If the prices on the market is higher than the fundamental values it will be considered as an overvaluation, compared to if the prices are lower than the fundamental values in which case it will be considered as an undervaluation. This is the same approach as Claussen (2012) and Turk (2015) used. They compared their fundamental values to the actual prices on the market. They also argue that there exists an overvaluation when the actual prices are higher than the values predicted by the ECM.

This paper will only consider these factors when determine overvaluation or undervaluation. The actual prices on the market will be compared with the fundamental values that are defined by the ECM, and all conclusions of valuation will be drawn based on these values.

3.3 Characteristics of the Swedish Real Estate Market

The Swedish rental market is regulated; the level of the rent is collective negotiated and in Swedish law it is stated that the rent must be fair. The most important in defining fair regarding the rental market is the use-value[1]. The law states that the rent should take condition and comfort into account (Bergendahl, 2012). Due to this, it becomes less attractive for real estate owners to rent out houses instead of selling them. Bergendahl (2012) shows that between 1998-2011 the number of rental apartments has decreased with 67.000. During the same period, the

[1] Bruksvärde in Swedish.

number of co-operative buildings[2] has increased with 259.000. This has led to long waiting time for a rental apartment. In Stockholm, the waiting time for an average apartment is 307 weeks and in the inner city it is 11 years. This can be compared to other major cities as Oslo, Copenhagen, Helsingfors, Brussel and Berlin which have 0 weeks waiting time. Further, Amsterdam and Madrid have 1-5 weeks waiting time (Bergendahl, 2012). Between 1995-2010, the real estate prices have increased by 144%, while rents only increased with 13%. This strengthens the argument that companies will continue to build houses rather than rental apartments (Englund, 2011). The rental market will not be further considered in this paper. However, it is important to have this fact in mind further on. It seems like the rental market has some challenges which could affect house prices.

During the time period studied, some major changes has happened in the market. The down payment required when purchasing real estate has decreased. In 1997 a 25 percent down payment was required and in 2009 it had decreased to 10 percent (Frisell & Yazdi, 2010). However, in 2010 a new law was implemented. To prevent households from having too high debts, it was stated by law that the down payment needed to be at least 15 percent (Neurath, 2012). Regardless of this law, the down payment has still decreased since the late 90's. Important to comment here is that one could still loan the 15 percent down payment, but in form of an unsecured loan. Another change is the repayment period that households have. During the period between 2002-2009 the repayment period increased from 49 years to 87 years (Frisell & Yazdi, 2010). According to Frisell & Yazdi (2010), this could have the potential effect that a household could pay 40 percent more in real terms for the same property before and after the change. In 2016 a new law regarding the repayment period entered. All individuals that took a loan that exceed 70 percent of the house value must amortize 2 percent a year, and individuals that took a loan that exceeds 50 percent must amortize 1 percent a year (Crofts 2016). According to Frisell & Yazdi (2010), the increase in repayment period and decrease in down payment leads to more access to the real estate market for more people. This would mean that more buyers enter the market and the demand increases. At last, from 1997 until 2008 the property tax decreased in several steps and in 2008 it where substituted with another tax that was lower for most of the people (Frisell & Yazdi, 2010). This increased the cash flow for the households. These changes will not be included in the econometric model, but could have significant effect on house prices when they were implemented.

3.4 Demographic and Real Estate Stock

As mentioned earlier in section 1, I will only include income, financial wealth and interest rate as fundamental factors. This means that I will leave population and housing stock out of the model, even though economic theory in section 3.1 suggest it should be included. I had to do this due to data unavailability. I have to assume that the market is in equilibrium in the long-run and by this I can exclude housing stock and population. One problem with the data is that

[2] An apartment that the owner uses but lies in a cooperate building.

population is reported yearly[3] which means that the sample size decreases. Data on the real estate stock is also limited. For Sweden it only exists on yearly basis and from more recent years. Due to this, I will not be able to add these variables in my model. This will be a limitation in this paper. Because of this limitation, I will further discuss the development of these variables and their effects in Sweden. By this, I hope to get an insight in what way my results may be biased.

Leonhard (2013) reports an extensive analyze of the changes in demographic and supply of real estate and their effects. In general, Leonhard (2013) concludes that the high demand of real estate depends on the increase in income rather than the shortage of properties. He further states that the property-to-population-ratio has had a small increase in recent years, although it is still on historical low values. The ratio has decreased during the 90's and stabilized during 00's. Nonetheless, there are big local differences reported. In 13 out of 21 counties the real estate prices moderated due to demographic and real estate stock changes. In most counties, these variables have little or no effect, but in larger cities the effect is different. For example, Leonhard (2013) reports that in Stockholm the property-to-population-ratio explain up to 21 percent and in Skåne this can explain about 12 percent of the real estate price increase. This arises due to urbanization.

It seems to be reasonable to assume that the demographic and housing stock are in equilibrium in the nation as a whole. However, it seems to be regional differences which could drive the results.

4. DATA

The time period studied is the first quarter in 1986 till the fourth quarter in 2016, with the exception of financial wealth which starts in the fourth quarter in 1986. The data is time series data and is quarterly reported. The variables source and description can be seen in Table 2. All variables except interest rate are in logs. All variables are in real values. Income, financial wealth and real estate prices are deflated with CPIF, which is a consumer price index with fixed rate. I choose to use CPIF because it has a smoother development and is not sensitive to fluctuation in rate (SCB, 2016). The house price index calculates price development on existing properties, which means that development on new buildings cannot be studied with this variable. Advantages with this variable are the available long time period and that it has been used in previous studies and therefore one can compare the results.

Interest rate will be the offer-rate by Swedbank. In Sweden the bank market is often described as an oligopoly. The four big banks have 70 percent of the lending and borrowing market in Sweden during 2016 (Swedbank, 2017). Therefore, one can assume that offered interest rate should not differ significant between the banks. Swedbank is chosen as a source because of the long time period that is available. A correlation test between Swedbank's and Nordea's offer-

[3] I have tried to estimate it into quarterly data using a cubic spline. However, it does not work well in the model due to collinearity.

rate during the period that is available from Nordea indicates a correlation of 99 percent. This strengthens the argument that the different banks offer-rates moves in the same direction. A flaw with using offer-rate is that the borrower often negotiates their rate. However, I think it is fair to assume that the offer-rate is closer to what the borrower pays than the repo-rate offered by the central bank. Considering these arguments, I will use Swedbank's data. The data contains both fixed and floated rate which can capture how much the borrower is effected of short fluctuations.

Financial wealth measures the households' assets. I have not found a variable that covers the whole time period that I will study. Given that different sources include different assets in this variable, to merge data from different sources has not been an option. I have also not been able to get the same data as Claussen (2012) and Turk (2015) used due to the cost of getting it. Therefore, I will use the Swedish stock market index (OMX30) as an approximation of financial wealth. According to Statistic Sweden's data, most of the household's financial wealth, expect for the value of their property, is stock, funds, and insurance savings. All these are exposed to financial markets, so this could be a valid approximation. In Figure 1 to 4 is the variables presented.

FIGURE 1: INTEREST RATE

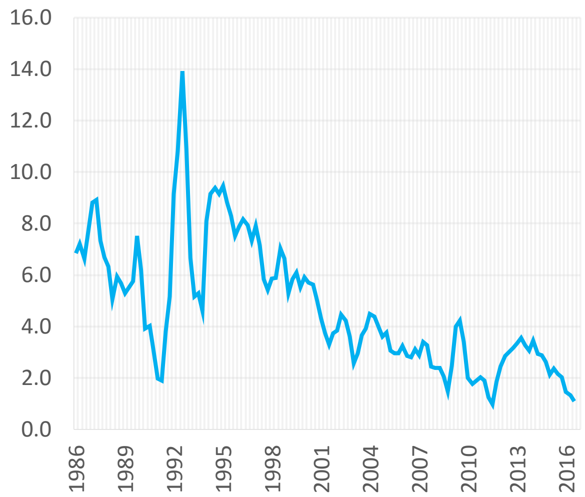


FIGURE 2: REAL ESTATE PRICES

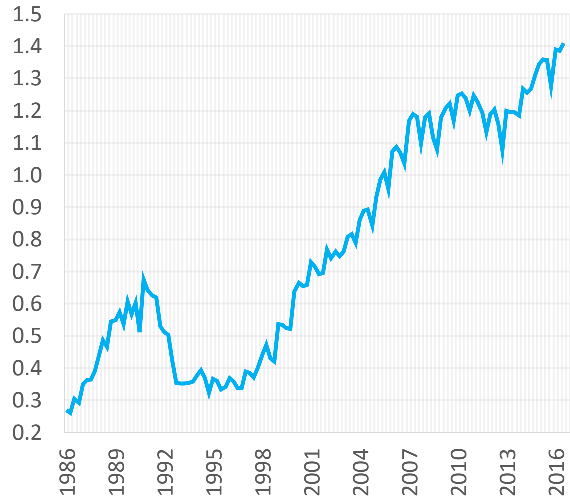


FIGURE 3: FINANCIAL WEALTH

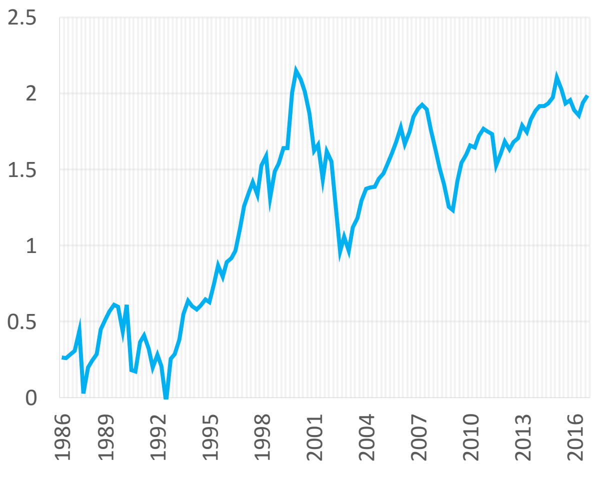


FIGURE 4: INCOME

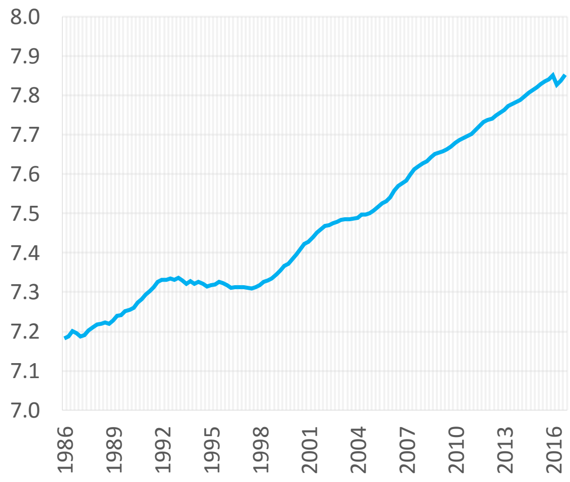


TABLE 2. VARIABLE DESCRIPTION.

Variable	Explanation
Real estate prices	Statistic Sweden's house price index (FASTPI). Calculate value development for permanent houses. 1980=100. The variable explains previous results and will be treated as t-1. The values are deflated with CPIF and are in logs. (Source: Statistic Sweden).
Disposable Income	Nominal disposable income households. Values are deflated with CPIF and are in logs. The values are seasonally adjusted by moving average smoother. (Source: Statistic Sweden).
Interest rate	The variable is combined of offered 5-year and 3-month interest rate. It is weighted by the number of people who has fixed rate and floated rate. Rate that is fixed longer than 3 months it is seen as fixed. Rates are adjusted for inflation to real rate. 5-year interest rate (Source: Swedbank) 3-month interest rate (Source: Swedbank and Swedish central bank) Inflation (Source: OECD) Fixed/Floated weights (Source: Swedish central bank)
Financial Wealth	Swedish stock index (OMX30). The index includes the 30 most traded stocks in the Swedish stock exchange. Values are deflated with CPIF and are in logs. (Source: Nasdaq OMX Nordic).
CPIF	Consumer price index with fixed interest rate. (Source: Statistic Sweden).

5. Empirical strategy

5.1 Time series behavior

To be able to use a standard econometric approach, as OLS, the variables needs to be stationary. A variable is said to be stationary if distributions like mean, variance and autocovariances are constant over time (Brooks, 2008). Time series data tend to be non-stationary and if one uses some regular econometric methods on non-stationary variables, one can end up with spurious regression (Brooks, 2008). To be able to use the non-stationary data one needs to make it stationary. However, this process may harm the variable and important components of the variable could disappear.

Another approach to handle non-stationary data is to use a cointegration technique. If variables move together over time, a combination of non-stationary variables may be stationary and are said to be cointegrated (Brooks, 2008). To study cointegration, an error correction model can be used.

5.2 Stationarity

There are two types of non-stationarity; random walk with drift and trend-stationary process (Brooks, 2008). A random walk with drift is a process were a shock stays in the system. These variables are a process with a stochastic trend or a unit root. A variable, y, will therefore be the sum of past shocks plus a start value of y. One way to make non-stationary variable stationarity is by using first difference (Brooks, 2008). If a variable is stationary, it is said to be integrated of order zero I(0). Although, if the variable is non-stationary but becomes stationary after differencing ones, it is said to be integrated of order one I(1). More general, a variable is said to be integrated of order d I(d) if it needs to be differenced d times (Brooks, 2008). Another type of non-stationarity is a trend-stationary process, which is a variable that is stationary around a linear trend. These variables can be made stationary by de-trending. To test for non-stationary, I will use df-gls. The model tests the equation in Equation 6. It tests for lags on the first difference detrended variable. The null hypothesis that is tested for is $\beta = 0$.

$$\Delta y_t = \alpha + \beta y_{t-1} + \varsigma_1 \Delta y_{t-1} \dots \varsigma_k \Delta y_{t-k} + \varepsilon_t \tag{6}$$

5.3 COINTEGRATION

If a combination of non-stationary variables that are integrated of the same order and the combination of them are stationary, the variables are said to be cointegrated (Brooks, 2008). If variables are cointegrated there exists a long-run relationship (Brooks, 2008). To test for cointegration one can use Engle-Granger 2-step method. To do so, one estimates a model with non-stationary variables and then tests if the error term is stationary. Hence, if all variables are non-stationary and integrated of order one I(1) and u_t is stationary and integrated of order zero I(0), then the variables are cointegrated (Brooks, 2008). To test for stationary in the residual one can use augmented dickey-fuller. Still, one needs to use the critical values that Engle-Granger (1987) provided.

Another test for cointegration is to use Pesaran et al's (2001) approach with an autoregressive distributed lag model (ARDL). To do this, one estimates the preferred ARDL model and then compute the F-statistic for the joint null hypothesis. The null hypothesis tests for that the speed of adjustment and the long-run coefficients differ from zero (Kripfganz & Schneider, 2016). The coefficient for the speed of adjustment indicates if the model is dynamically stable. It is a one sided t-test where the null hypothesis is that the speed of adjustment is zero and the alternative hypotheses is negative (Nkoro & Uko, 2016). It does not test for a positive speed of adjustment, since that would mean that the model is explosive and do not correct to the equilibrium.

Peseran et al's (2001) bound test approach for cointegration reports both an upper and a lower critical value. If we can reject the null hypothesis for both the lower and upper value, we can say that it exists a long-run relationship between the variables, regardless of if the variables are I(0) or I(1). If the critical value is below the lower bound, there does not exist a long-run relationship and if the critical value falls between the bounds the result is inconclusive. Worth mentioning is that often when referring to cointegration, one refers to a long-run relationship where the variables are integrated of the same order. If it is a long-run relationship where the variables are integrated of different orders one often refers to only a long-run relationship. However, in this paper will I use the terms equivalent.

5.4 ERROR CORRECTION MODEL

Cointegrated variables are often modelled with an error correction model. One underlying assumption for the model is that there exists a long-run equilibrium for the variables. The classic approach is the Engle & Granger 2-step method, which can be displayed in equation 7. In the equation, y_t is the dependent variable and x_t is the independent variable. The equation comes from Brooks (2008).

$$\Delta y_t = \beta_1 \Delta x_1 + \beta_2(y_{t-1} - \gamma x_{t-1}) + u_t \tag{7}$$

Where

Δ =First difference
$y_{t-1} - \gamma x_{t-1}$ = Error correction Term
γ = Cointegration coefficient (Long-term relationship)
β_1 =Short-run relationship
β_2 =Speed of adjustment

Some critic against this method is that it can be a biased if the correlation between the variables goes in both directions. Another critic is that the power becomes weaker when using a smaller sample (Brooks, 2008). Further, bias or misspecification in the first step transmits to the second step estimation. All variables also need to be integrated of the same order to use the approach (Nkoro & Uko, 2016). Kripfganz & Schneider (2016) argues that to determine in which order the variable are integrated can be challenging, which can lead to pre-estimation problems.

Another approach that can be used is an autoregressive distributed lag model. An advantage of this model is that one can use variables that are both integrated of order zero and order one (Kripfganz & Schneider 2016). This decrease the risk of pre-estimation problems and one only needs to determine that are not integrated of order two. On the other hand, Brooks (2008) argues that variables that are integrated of order two are very rare if they even exist. Another advantage with the ARDL model is that one can include different lags for the different variables, which is not possible for in the Engle & Granger 2-step method (Kripfganz & Schneider 2016). A general ARDL model can be seen in Equation 8. The equation comes from Kripfganz & Schneider (2016).

$$y_t = c_o + c_1 t - \alpha(y_{t-1} - \theta x_t) + \sum_{i=1}^{p-1} \psi_1 \Delta y_{t-i} + \sum_{i=1}^{q-1} \psi'_1 \Delta x_{t-i} + u_t \tag{8}$$

Where

p and q= Number of lags for variable y and x
t =max(p,q)
c_0 =Constant
c_1 =Time trend
α =Error correction term
θ =Long-run coefficient
ψ =Short-run coefficient
Δ= First difference

An ARDL model can be displayed in five different ways and are listed below. The different cases come from Pesaran et al (2001).

Case 1: No intercept and no trend ($c_0 = 0$ and $c_1 = 0$)
Case 2: Restricted intercept and no trend ($c_0 =$ is restricted and $c_1 = 0$)
Case 3: Unrestricted intercept and no trend ($c_0 \neq 0$ and $c_1 = 0$)
Case 4: unrestricted intercept and restricted trend ($c_0 \neq 0$ and $c_1 =$ is restricted)
Case 5: unrestricted intercept and unrestricted trend ($c_0 \neq 0$ and $c_1 \neq 0$)

In case 1 it is assumed that there is no trend and no constant in the model. This restricts the long-run relationship to be stationary with the mean of zero (Stata, 2013). It does also restrict the model to go through origin. Case 2 and 3 follows the same procedure, with one exception. In case 2, the constant is placed in the long-run while in case 3, it is placed in the short-run. In case 4 and 5, both a trend and a constant are included. In case 4, the trend is placed in the long-run and in case 5, the trend is placed in the short run.

Pesaran et al (2001) argues that to test for cointegration, using the bound-test approach, the model should not suffer from serially correlated errors. The critical values provided by them are obtain under the assumption that the model has no serial correlation. If the model has serial correlation the cointegration test may be misleading. To test for serial correlation a Breusch–Godfrey test was used in this paper. Further, they suggest that one should test for structural breaks. This will be tested by cusum control chart. Pesaran et al (2001) suggest that one should test for heteroscedasticity, but instead I used robust standard errors to correct for this. At last, a test for functional form misspecification is suggested. To test this, Ramsey's (RESET) test was used. Further assumption is assumed from Gauss-Markov's assumption.

5.5 Econometric model

To investigate the long-run relationship in the Swedish real estate market I have, as suggested by the life-cycle model, derived my model from equation 5. It displays the inverted demand function of households. The theory suggests that real estate stock and construction cost should be included on the supply side and population, income, financial wealth and interest rate should be included as demand factors. Due to data unavailability, population and real estate stock was not included. Instead I, as Claussen (2012), assumed that in the long-run the market is in equilibrium and demand is equal to supply. Therefore, I am able to exclude them from the model. Construction cost was also excluded from the model, which is supported by previous research. For example, Claussen (2012) showed that it did not belong in a Swedish model and estimated an economic insignificant result[4]. He argued that it could be due to lack of competition on the market. Swedish Competition Authority (2009) supports this view and also argues for the lack of competition within the Swedish construction business. The estimated model included the demand factors X_t from equation 5. The models that are estimated in this paper are listed below.

[4] This paper does also test for construction cost with the same result.

$$\Delta RP_t = C_o - \alpha(HP_{t-1} - \theta income - \theta rate) + \sum_{i=1}^{p-1} \psi_1 \Delta HP_{t-i} + \sum_{i=1}^{q-1} \psi'_1 \Delta Income_{t-i} + \sum_{i=1}^{q-1} \psi'_2 \Delta rate_{t-i} + u \quad (9)$$

$$\Delta RP_t = C_o - \alpha(HP_{t-1} - \theta income - \theta rate - \theta Wealth) + \sum_{i=1}^{p-1} \psi_1 \Delta HP_{t-i} + \sum_{i=1}^{q-1} \psi'_1 \Delta Income_{t-i} + \sum_{i=1}^{q-1} \psi'_2 \Delta rate_{t-i} + \sum_{i=1}^{q-1} \psi'_3 \Delta Wealth_{t-i} + u_t \quad (10)$$

Where

RP = Real estate prices
C_o = a constant
α = error correction term
θ = the long-run coefficients
ψ = the short-run coefficient
p = the number of lag for the dependent variable
q = the lag for the independent variable
Δ = the first difference
u_t = the error

In this paper the focus will be on θ, which is the long-run cofficent and α, which explain the adjustment to equilibrium. In economic theory one expect income and financial wealth to have a positive sign. Interest rate is expected to have a negative sign. The error correction term, α, is expected to be -1<v_t<0, otherwise the model would be explosive and not display a meaningful interpretation. The autoregressive distributed lagged model is from Pesaran et al (2001) and was implemented as Kripfganz & Schneider (2016) suggests. The variables will measure elasticities, as for Turk (2015) and Claussen (2012). The elasticities show the percentage change in real estate prices when there is a percentage change in a fundamental factor (income, financial wealth and interest rate).

The model will display net-effects since demand and supply are merged. This means that the total effect of a change, in both the demand and supply side, is reported. The model will further assume that this is the fundamental factors that explains the real estate prices and that disequilibrium depends on irrational behavior rather than a miss-specified model.

5.6 Lag selection criteria

To be able to test for stationary but also conduct the ARDL model one need to detriment the number of lags to include in the model. Pesaran et al (2001) argues that Schwarz's Bayesian information citera (SBIC) is best suited for an ARDL approach. Stata (2013) argues that SBIC has a theoretical advantage compared to other methods. Therefore, SBIC is preferable to use. To test for the number of lags, SBIC tests the fit for lag p and compares it with the fit for lag p-1. The null hypothesis is that all coefficients for the lags are zero. SBIC can be seen in Equation 11 which comes from Stata (2013).

$$SBIC = -2\left(\frac{LL}{T}\right) + \frac{\ln(T)}{T} t_p \quad (11)$$

where,

$LL = -\left(\frac{T}{2}\right)\{\ln(|\hat{\Sigma}|) + Kln(2\pi) + K\}$

$T =$ Number of observation

$K =$ Number of equations

$\hat{\Sigma}$ =Maximum likliehodd of $E(u_t u_t^{'})$

u_t = Kx1 vector of disturbance

t_p =Totalt number of parameters in model

This lag selection method can be used even if the variables are non-stationary, which we have reasons to believe (Stata, 2013).

5.7 Cusum Control Chart

The cusum control chart can be used to test the stability for mean and the variance in coefficients. This approach is good at finding small changes in mean or variance. It tests the accumulated mean or variance against the current and previous result (Wachs, 2010). The cumulative sums of deviation from the sample is plotted against the target value (Wachs,2010). From NCSS (2017) the steps to calculate the cusum chart is provided. Firstly, one calculate z in Equation 12. Then one plots it against the lower and upper 95 percent critical bounds. If the value from Equation 12 goes outside the range of the bounds, there exist a structural change.

$$Z_i = \frac{\bar{X}_\iota - \bar{\bar{X}}_\iota}{\widehat{\sigma_{\bar{X}}}} \quad (12)$$

where

$\bar{X}_\iota = \frac{\sum_{j=1}^{n} X_{ij}}{n}$

X_{ij} = Measure the j^{th} sample of the i^{th}subgroup.

$\bar{\bar{X}}_\iota$= Summation of a number of series of subgroups. (Summation of a number X_{ij})

$\hat{\sigma}$= Standard deviation of a subgroup

5.8 Limitations

One limitation with this paper is the use of the house price index. The index only consists of houses and not apartments. In larger cites, apartments are more common and this choice of variable may miss this effect. Also this index is represented in national level, meaning that we assume that all regions are affected in the same manor. Another limitation will be the assumption that the demand and supply are in equilibrium and therefore we can leave population and real estate stock out of the model. As mention in section 3.4, it seems to be a reasonable assumption in Sweden as a whole, but not in all regions. In Section 2, we also mentation that this assumption often leads to an income elasticity around 1, which may not be true. Finally, the assumption that the error correction model displays the true fundamental value and that a deviation between actual values and fundamental value is a sign of miss-valuation will limit the analysis to this definition.

6. Results

The analysis was done in six steps. First, the number of lags were determined. Secondly, a test for stationarity was made. Further, the ARDL model was estimated and then the robustness tests were made. After that, I tested for cointegration. At last, the valuation of the real estate market was studied.

6.1 Lag selection

As mentioned in section 5.6, I will determine the number of lags using SBIC. This to avoid serial correlation both in the stationarity test, but also in the ARDL model. There is no clear cut in choosing maximum number of lags, but Wooldrige (2014) argues that for quarterly data between four and eight lag is reasonable. Therefore, I limit the maximum number of lags to eight. Although, increasing the maximum number of lags to 10 do not yield any different result. SBIC suggests that one should include five lags for real estate prices, six lags for income, two lags for interest rate and one lag for financial wealth. This specification will be used further in this paper.

6.2 Stationarity

As mentioned in section 5.1, time series data are often non-stationary and in this section I will test the data for stationarity. The result from a DF-GLS test is presented in Table 3. This method includes a trend variable, controlling that the variable follows a unit-root rather than is trend-stationary. First, the variables are tested to see if they are stationary which means that they integrated of order zero I(0). After that, I tested the variables in their first difference to see if they were integrated of order one I(1). The maximum number of lags allowed in the test is four and the null hypothesis is that the variable is non-stationary. The number of lags included for each variable is as determined in section 6.1.

Table 3. Stationarity test.

Variable	I(0)	I(1)
Real estate prices	-1.491	-10.090*
	(-2.990)	(-2.991)
Income	-1.703	-3.366*
	(-2.995)	(-2.996)
Interest rate	-4.915*	-6.910*
	(-2.990)	(-2.991)
Financial Wealth	-2.245	-7.325*
	(-2.697)	(-2.698)

5% rejection value for lag 4 in parentheses. *Note: Rejection value for lag 1.

The result in Table 3 indicates that all variables are stationary in their first difference, already using only one lag. That means that none of the variables are integrated in a higher order than one. We can also see that all variables are non-stationary, except for interest rate. This result would imply that the variable interest rate could not be used in an Engle & Granger approach, since it is not integrated of the same order as the other variables. However, in the ARDL approach, all variables could still be used because both I(0) and I(1) are allowed. The result from the DF-GLS test is complimented with an Augment Dickey Fuller test and a Phillips-Perron test. The complemented tests received similar results. However, when not controlling for a trend in the Augment Dickey Fuller test and a Phillips-Perron test, interest rate produces inconclusive results. This could be an indication that interest rate is trend-stationary rather than follow a unit-root. The result indicates similar conclusion as previous studies; that the variables are non-stationary except for interest rate which produce inconclusive result.

6.3 AUTOREGRESSIVE DISTRIBUTED LAGGED MODEL

By studying figure 1-4, we have no reason to believe that this model should have zero mean and be stationary since all variables seem to trend. This is assumed in case 1 and therefore one should not, according to economic theory, use it[5]. Case 1 also forces the model to go through the origin. Claussen (2012) and Turk (2015) used a constant as a deterministic trend, which is similar to case 2 and case 3. Both papers included the constant in the long-run, as case 2 does. One cannot determine if the long-run relationship includes a constant and a trend by only studying the graph. Therefore, this was tested to see how the model behaved. Table 4 presents the results from model 1. The coefficients display elasticity between the fundamental value and real estate prices. For example, the income elasticity explains the effect on real estate prices when income changes.

[5] Case 1 is estimated and produce economic insignificant result as expected.

TABLE 4. LONG-RUN ELASTICITIES. MODEL 1.

Variable	Case 2	Case 3	Case 4	Case 5
Real estate prices				
Income	1.14***	1.14***	-0.051	-0.051
	(0.07)	(0.07)	(0.168)	(0.187)
Interest rate	-0.079**	-0.079**	-0.094	-0.094
	(0.004)	(0.004)	(0.003)	(0.004)
Adjustment coefficient	-0.112**	-0.112**	-0.089	-0.089
	(0.044)	(0.004)	(0.06)	(0.06)
Constant	-7.28***			
	(0.484)			
Trend			0.006	
			(0.0007)	
Observation	117	117	117	117
Adjusted R-squared	0.3998	0.3998	0.3873	0.3873

Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

The result indicates that when adding a trend and a constant (case 4 and 5) the model performs poorly. All variables become statically insignificant and the income elasticity become negative which goes against economic theory. This result indicates that a trend should not be in the cointegration relationship. It seems like the model with a constant as a deterministic trend (case 2 and 3), which have been used in previous papers, is the most appropriate model. Both produces economic and statically significant coefficients. The coefficient of income indicates that a 1 percent increase in income leads to a 1.14 percent increase in real estate prices. In similar, a 1 percent increase in interest rate leads to a 7.9 percent decrease in real estate prices. The elasticities in these cases are similar to previous results. One can see that Turk (2015) and Claussen (2012) reported an income coefficient of 1.13 respectively 1.3 in table 6. The coefficients that were found for interest rate were 0.04 and 0.06. The error correction term indicates a correction to equilibrium of 11.2 percent each quarter. That means that it is a correction of 46 percent per year. This is higher than previous results where Turk (2015) and Claussen (2012) found a speed of adjustment of 30 percent per year.

Further, model 2 is estimated, which includes financial wealth. The result can be seen in Table 5.

TABLE 5. LONG-RUN ELASTICITIES. MODEL 2.

Variable	Case 2	Case 3	Case 4	Case 5
Real estate prices				
Income	-0.55	-0.55	3.59	3.59
	(0.12)	(0.121)	(0.17)	(0.17)
Interest rate	-0.167	-0.167	-0.21	-0.21
	(0.004)	(0.004)	(0.004)	(0.04)
Financial Wealth	0.52	0.52	1.2	1.2
	(0.018)	(0.014)	(0.025)	(0.025)
Adjustment coefficient	-0.048	-0.048	-0.062	-0.062
	(0.068)	(0.067)	(0.068)	(0.068)
Constant	5.42			
	(0.83)			
Trend			-0.034	
			(0.001)	
Observation	117	117	117	117
Adjusted R-squared	0.4111	0.4111	0.4157	0.4157

Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

The result for model 2 is that all four cases produce statically insignificant result. Due to the insignificant result the model does not indicate a long-run relationship and we can no longer use the model for cointegration testing. My approximation of financial wealth may be the answer to the poor estimation. Economic theory and previous papers suggest that financial wealth belongs in the model. However, Claussen (2012) found a low p-value on financial wealth and questioned if it should be included in the model. His cointegration test suggested that it should be included and he used it, but the result was weak. This together with my approximation of financial wealth can be the answer to the insignificant result.

Further, due to the insignificant result I will drop financial wealth from the model and instead use model 1. This will have an effect on the model if financial wealth belongs in the model. Claussen (2012) reports that the financial wealth has been of less importance since 1996. He also reports that a 1% increase in financial wealth should yield a 0.12% increase in house prices.

Although, the result from Claussen (2012) indicates that financial wealth seems to have a little or no effect on prices and therefore it may not belong in the model for the real estate market.

In the remainder of this paper model 1 will be further considered. The paper will test for both case 2 and 3, but the estimations produce the same result, except for the constant term. Therefore, only the result of case 2 will be presented to give importance to the elasticities which are of interest in this paper.

6.4 Robustness

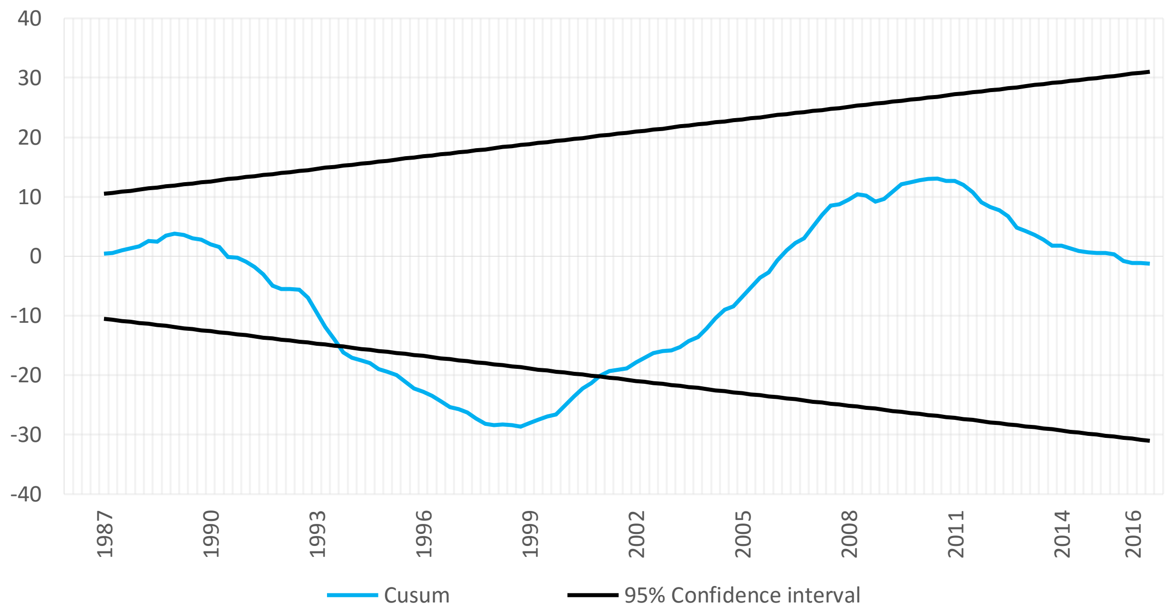
6.4.1 Serial Correlation

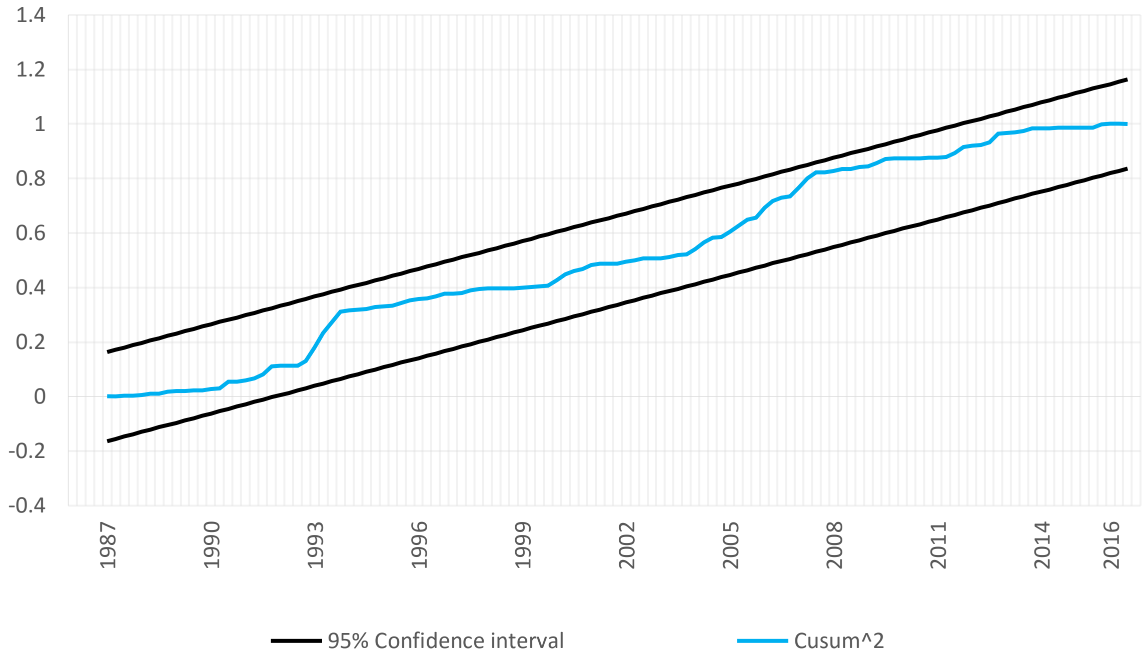
Pesaran et al (2001) suggests that one should test for serially correlated errors. Both bound-tests assume that the model is serially independent and therefore, the result from the cointegration test could be misleading if this is not fulfilled. I will test for serially correlated errors by using a Breusch-Godfrey test. The null hypothesis means that it does not exist any serially correlated errors and the alternative hypothesis is that the model is suffering from serial correlation. I test for up to a maximum of 4 lags and use 10 percent critical values. For model 1 we can accept the null hypothesis of no serial correlation at a 10 percent level and conclude that the model does not suffer from serial correlation.

6.4.2 Structural Breaks

Further Pesaran et al (2001) suggests that one should test for structural breaks. This test could also be an indication if the variables are stable in the long-run. Previous critic against the error correction model has been that the elasticities could be affected by periods where the market is over- or undervalued, and might therefore be unstable. I tested the model for structural breaks, using a cusum control chart. The result is then compared to a 95 percent confidence interval. If the values are outside the interval, it could mean that some structural changes occurred. The result for the mean can be seen in Figure 5 and for the variance in Figure 6.

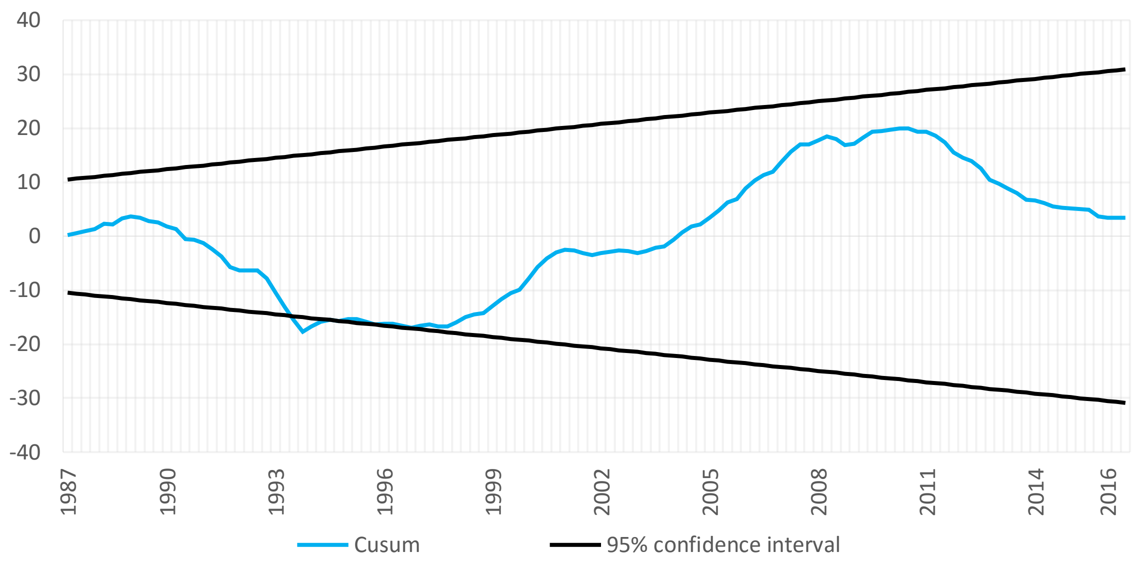
Figure 5. Cusum chart control Model 1. Test for mean.





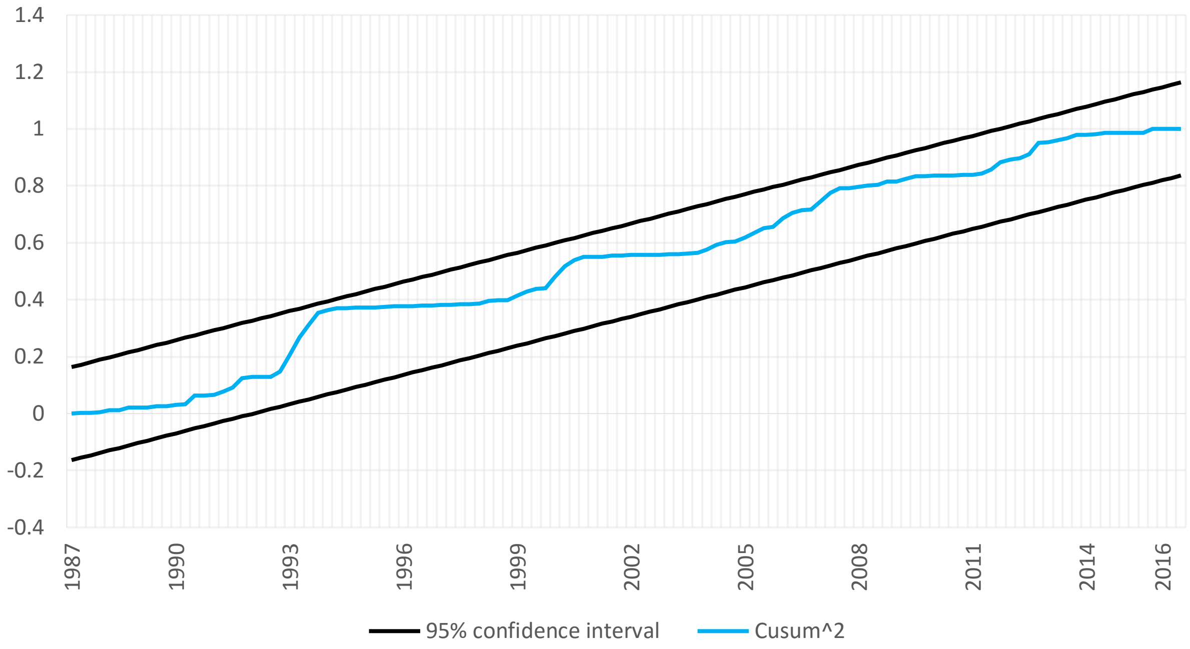
I tried to correct the structural break by introducing a dummy variable controlling for the break. Joyux (2001) argues that structural breaks in VAR models often are treated with a dummy variable. The variable is one during the period of structural break and zero otherwise. The result with a dummy variable can be seen for the mean in Figure 7 and for the variance in Figure 8.

FIGURE 7. CUSUM CHART CONTROL MODEL 1 WITH DUMMY. TEST FOR MEAN.



The coefficients are still unstable when including a dummy variable, however the model seems to be improved. The variance continues to be stable even after the dummy variable. Including a dummy variable however does not correct the break fully.

FIGURE 8. CUSUM CHART CONTROL MODEL 1 WITH DUMMY. TEST FOR VARIANCE.



I re-estimated Model 1 with the dummy variable to see how the elasticities are effected, the result can be seen in Table 6. If we compare the elasticities with the results in Table 4, we can observe that they do not differ significantly. This can be an indication that the structural break does not affect the elasticities significantly. It could also be a result of an insufficient dummy variable. Further in this paper, the model without the dummy variable is considered. The dummy variable is not statistically significant and it do not correct the structural break fully. Therefore, I do not want to include the dummy variable.

TABLE 6 LONG-RUN ELASTICITIES MODEL 1 WITH DUMMY VARIABLE.

Variable	Model 1(Dummy)
Real estate prices	
Income	1.19***
	(0.08)
Interest rate	-0.075*
	(0.024)
Adjustment Coefficient	-0.117*
	(0.035)
Constant	-7.466***
	(0.55)
Structural Break	2.363
	(0.001)
Observation	117
Adjusted R-squared	0.4294

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

6.4.3 FUNCTIONAL FORM MISSPECIFICATION

Pesaran et al (2001) further argues that a test for functional form misspecification should be considered. I used a Ramsey Regression Equation Specification Error test (RESET) to test for misspecification. By using three power of the predicted variable I can, at a 10 percent level, conclude that the model does not suffer from misspecification. However, this test alone does not insure that the model is correctly specified.

6.4.4 METHOD APPROACH

I estimated a model using similar methods as Turk (2015) and Claussen (2012) to see if the results are sensitive to the method specification. I used Schaffer's (2010) Engle-Granger method (EG) and Wang & Wu's (2012) cointegration regression using dynamic OLS (DOLS). Two lags are included in the Engle-Granger model and the DOLS model include one lead and one lag, as suggested by SBIC. The long-run coefficients are presented in Table 7.

TABLE 7 LONG-RUN ELASTICITY FROM ENGLE-GRANGER APPROACH AND DYNAMIC OLS.

Variable	EG	DOLS
Real estate prices		
Income	1.36***	1.19***
	(0.06)	(0.162)
Interest rate	-0.038***	-0.052***
	(0.005)	(0.016)
Constant	-9.19***	-7.87***
	(0.47)	(1.28)

Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

The results display similar elasticities to Claussen's (2012), Turk's (2015) and my ARDL model. This indicates that the model is not sensitive to method selection. Further, it is an indication that the ARDL approach is a valid substitute to previous methods which assumed that all variables are integrated of the same order.

6.4.5 SENSITIVITY TO TIME PERIOD

One critic against the error correction model approach is that a real estate bubble would build during a long period of time. Therefore, the coefficients would be effected if the market were not correctly valued during the sample period. To control this, I will estimate the ARDL model during different time periods. In the early 90's there was a major downturn in prices, which could be seen as a bubble. Therefore, I excluded the values from 1986 till 1992 and let the sample start in the first quarter of 1993 and end in the third quarter in 2016. The result from this estimation can be seen in Table 8.

Interest rate and speed of adjustment is statically insignificant. The elasticities do not change significantly compared to previous model with the longer time period. The income elasticity increased from 1.14 to 1.23. The elasticity for interest rate change from -0.079 to -0.063, indicating that interest rates effect on real estate prices becomes less when removing the bubble period in the early 90's. The speed of adjustment decrease, indicating that a disequilibrium is corrected more slowly. Overall, removing the bubble period has no drastic effect on the elasticities.

If one argues that the current real estate market is overvalued, one would want to exclude the most recent data. Around 2007-2008, there was a rather big downturn in real estate prices globally, but Sweden was not affected. One could therefore argue that Sweden's real estate market was not overvalued during this period. Due to this, I will estimate until the fourth quarter in 2009. The result can be seen in Table 8.

TABLE 8. LONG-RUN ELASTICITY DURING SHORTER TIME PERIODS.

Variable	Q1 1993- Q3 2016	Q1 1993- Q4 2009
Real estate prices		
Income	1.23***	2.256***
	(0.104)	(0.457)
Interest rate	-0.063	-0.021
	(0.004)	(0.004)
Speed of adjustment	-0.102	-0.397**
	(0.06)	(0.181)
Constant	-8.069**	-15.976***
	(0.734)	(3.285)
Observation	89	62
Adjusted R-squared	0.5259	0.6244

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

In this model interest rate becomes insignificant. The elasticities change quite drastic and we can see that the income elasticities become very large, indicating that a 1 percent increase in income should yield a 2.37 percent increase in real estate prices. The speed of adjustment also becomes high, indicating that the whole disequilibrium is corrected within three quarters. An explanation to the large elasticities may be found in figure 4. During the sample period chosen in this estimation we can observe that real estate prices have almost only increased.

Removing the period between 1986 until 1992 did not affect the result significantly. However, when estimating the model using data from 1993 until 2009 the elasticities changes drastic. This result could be an indication that the critic regarding that may be true. Nevertheless, much of the elasticities are insignificant and one should not draw to strong conclusions about this.

A problem with shortening the time period and dividing the sample is that we end up with a smaller sample size that cannot represent the long-run, which is the model's goal.

6.5 COINTEGRATION

I tested for a long-run relationship and the speed of adjustment coefficient to determent if there exist a long-run relationship. The test used was Kripfganz & Schneider's (2016) bound test. This test can only be used if there exists at most one cointegration. To determent the number of cointegrations I used Johansen's cointegration test. The result for Model 1, case 2 and 3, are ambiguous. For a lag order between three and six there is at most one cointegration, but with fewer lags the result is not clear. I will however assume that the model has at most one cointegration from this result. Important to comment is that Johansen's cointegration test requires that all variables are integrated in the same order. Previous tests indicate that we have reasons to doubt that all variables are integrated of the same order. Therefore, one should be careful with drawing conclusions upon this result.

Testing for cointegration using the bound test yields an F-value of 3.543 for case 2. This value is larger than both rejection values for I(0) and I(1) at a 10 percent level provided by Pesaran et al (2001). Therefore, we can reject the null hypothesis of no long-run relationship and instead conclude that there exists a long-run relationship. The error correction term is not tested when the deterministic term is restricted, which it is in case 2.

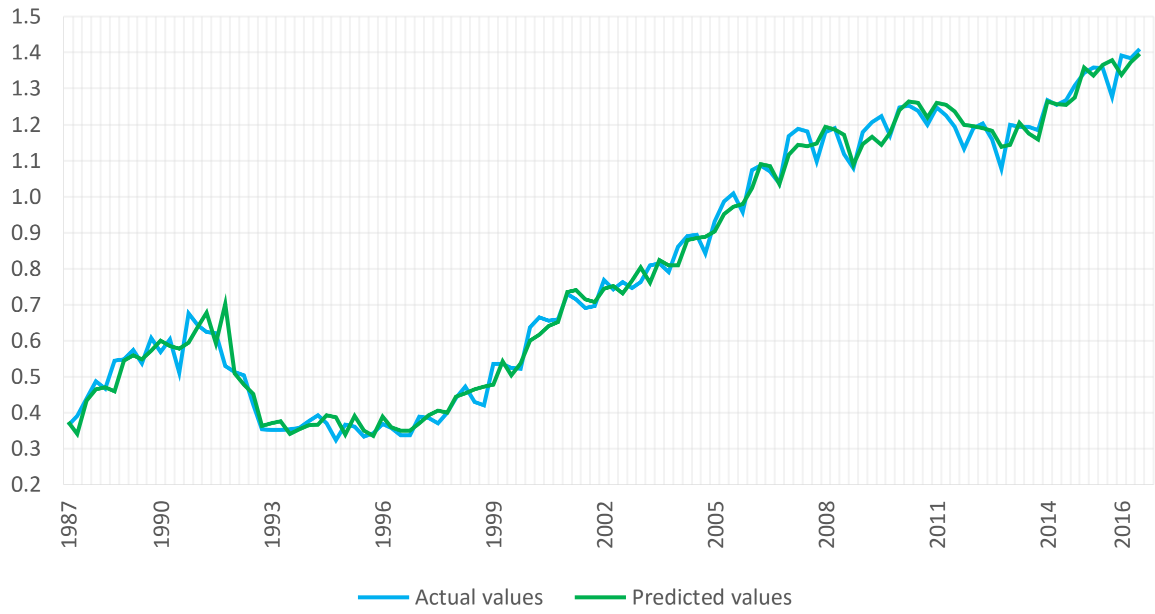
The bound-test for case 3 produce an F-value at 3.967 and compared to the rejection value in Pesaran et al (2001) it falls between the values for I(0) and I(1). The result is therefore inconclusive. The t-value at -2.389 is lower than the rejection in absolute terms meaning that one cannot reject the null hypothesis that the speed of adjustment is different from zero.

The cointegration tests indicates that case 2 has a long-run relationship and that case 3 does not. The deterministic term should therefore be treated as a long-run variable. Then we end up with a model similar to Claussen's (2012) and Turk's (2015), which both included the deterministic term in the long-run. Further, I will assume that case 2 is the best specified case for model 1.

6.6 Valuation

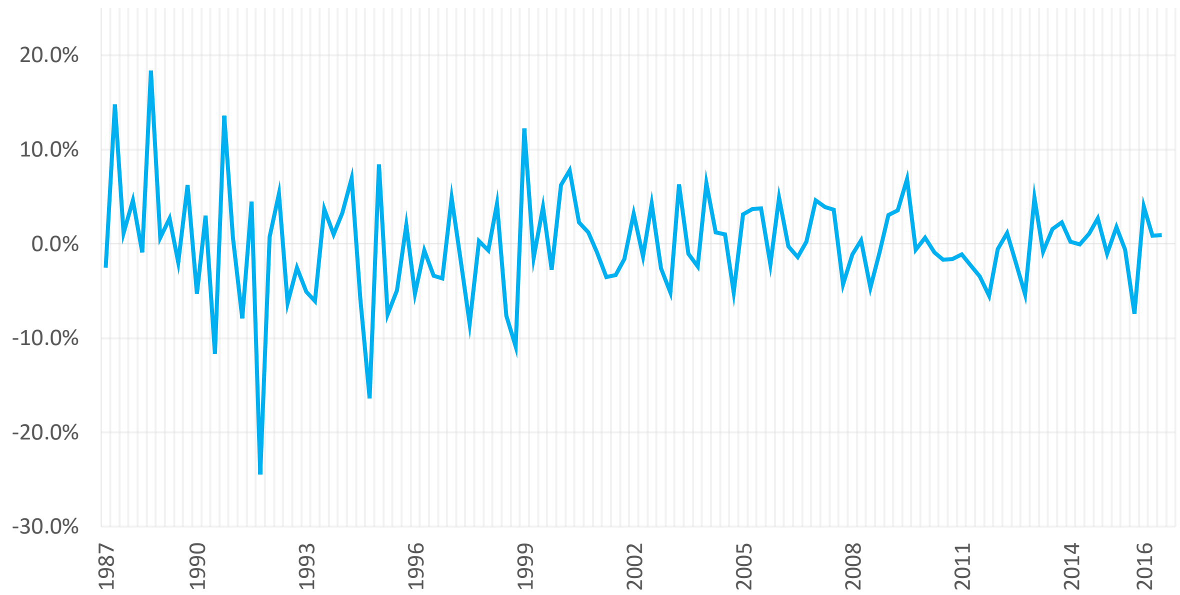
Further I studied the valuation of the real estate market. First, as mentioned in section 3.2, I will value the market by assuming that value from the ECM is the fundamental value and that a deviation from the actual value is a sign of miss-valuation. The actual values and the predicted values are presented in Figure 9. The actual values and the predicted values follow each other closely. This indicates that the model predicts the actual values well. However, this is as expected because the ECM always corrects the errors.

Figure 9. Predicted values against actual values.



In Figure 10, the valuation can be seen in percent. The valuation seems to fluctuate around zero. During the real estate bubble in the early 90's in Sweden the model indicates an overvaluation at 13.6 percent, meaning that the actual prices is 13.6 percent higher than the justified value predicted by the ECM. This is close to Turk's (2015) result, who found an overvaluation of 14.3 percent during the same period using the same approach. In the second quarter of 2015, Turk (2015) reported an overvaluation at 5.5 percent, while this model indicates an overvaluation at 2.2 percent. It seems like this model predicts a lower result than Turk's (2015), but not far from his result. My model suggests an overvaluation in the third quarter of 2016 at 0.96 percent.

FIGURE 10. VALUATION FROM MODEL 1.



7. ANALYSIS

7.1 AUTOREGRESSIVE DISTRIBUTED LAGGED MODEL

The main result of this paper is that an autoregressive distributed lagged model approach produce similar results as previous papers that used a standard cointegration approach. This result shows that by adopting the ARDL approach, one no longer needs to assume that all variables are integrated of the same order. This helps us to avoid pre-estimation problems regarding the order of integration. Therefore, one can include variables that are of different orders and estimate a real estate model. This could have an impact on future research since a real estate model now can include more variables. As mentioned in section 2, interest rate is stationary in the long-run and this has been a critic against the use of an error correction model. This paper has therefore overcome one of the major critics against the use of an error correction model in the real estate market.

In summary, modelling the real estate market with an autoregressive distributed lagged model seems to be a good substitute to the classic cointegration approach. The model displays similar result and attributes without having to assume that all variables are integrated of the same order.

7.2 CRITIC

First, the critic of assuming if all variables are integrated of the same order has already been discussed in section 7.1. Another critic against the error correction model is the high income elasticity that cannot be stable over time. In section 2, I mention that it is common to find a high income elasticity when excluding real estate stock and other supply factors, which this paper does. Therefore, this paper has not been able to correct for this. The theoretical elasticity is one and this paper report an elasticity of 1.14. This is close to the theoretical value, but above one, which may be explained by the exclusion of supply factors. Jacbosen & Naug (2005) argues that to overcome this issue, one should add the supply factors. However, this paper does not answer if it is true or not. Instead, this paper suggests that more research with the supply factors should be done to answer this question. Another explanation of the high income elasticity could be that households reallocate money to spend more on properties. Boverket (2012) argues that the preferences for real estates increased during the 00's. Households would therefore reallocate their money and spend more on real estates and as a result the elasticity would be above one. This paper cannot conclude if this is true, only determent that the elasticity is above one.

Another critic is that the elasticities could be affected if they are estimated during a period where there exists an over- or undervaluation. This paper tries to correct this by estimating shorter time periods and test for structural breaks. In section 6.4.5, we observed that the elasticities changed for both income and interest rate in a model using shorter time period. The result was statistically insignificant and the income elasticity is highly questionable from an economic point of view. Therefore, one should not draw to strong conclusion based on this result, but at least it indicates that the elasticities are sensitive.

Further in Section 6.4.2, we concluded that the model is suffering from a structural break, meaning that the coefficients are unstable. The sensitivity to shorter time periods and the structural breaks may indicate that previous critic against the error correction model is valid. The elasticities may be affected from periods where the market is over- or undervalued. The structural break that is found occurred around the real estate crises in Sweden, which could indicate that the effect occurs due to miss-valuation in the market. This paper cannot fully answer if this is true or not. We can however conclude that the elasticities are unstable.

The result from section 6.4.2 and 6.4.6 rise the question if it even exists a long-run relationship. If the relationship is not stable over time, does the relationship even exist? This paper suggests that it exists a long-run relationship due to the result in section 6.5 and the economic theory behind it. This would mean that we have a long-run relationship but the magnitude of that relationship changes over time.

7.3 VALUATION

According to the result in Figure 10, there is a small overvaluation of 0.96 percent in the Swedish real estate market. If one studies the valuation in figure 7 it moves around zero and during the more recent year it has fluctuate between approximate -5 percent and 5 percent. This is an indication that the valuation today is not an anomaly. According to the definition provided in 3.2, there is a miss-valuation in the market when the actual prices differ from the fundamental value predicted by the ECM. However, as one can see in Figure 10, is the market often in disequilibrium but tends to moves around equilibrium. The market will therefore often be overvalued or undervalued by the definition in this paper.

When only considering the elasticity and the change in the fundamental factors, it is a sign of high overvaluation. Between 1986 and 2016 real income has increase with 92.5 percent according to my data. With an income elasticity of 1.14 this would justify an increase of 105,5 percent in real estate prices. Between 1986 and 2016 the real interest rate has decreased with 5.75 percent and with a semi-elasticity of 7.9 percent, the decrease in interest rate would justify a price increase of approximately 45 percent. These two together would indicate that real estate prices should have increased with 150,5 percent. During this period, real estate prices have increased with 213 percent.

If past prices are an important factor for future prices could therefore be debated. According to the ECM, past prices should be considered. Although, one could argue that if the market is over- or undervalued, it should convert back to equilibrium and therefore the market takes past prices into account. If one argues that it is true that real estate prices move in cycles, one should expect that prices counting to move in the same direction as before within the cycle. Therefore, it would be rational to look at past prices.

Leonhard (2013) found that one third of the real estate price increase could be explained by retrospective and the expectation of the same development as previous periods. Janson & Persson (2011) argues that houses prices tend to have momentum, meaning that; if prices increase faster than fundamental, they tend to continue to increase faster the next period as well. This further strengthens the argument that people tend to use past prices to form their expectation and this lead to self-increasing behavior. Therefore, it may be appropriate to model the real estate market with and error correction model, which takes past prices into account.

A challenge with implementing past prices in the valuation model is that in both the up- and downward phase the movement will be self-increasing, meaning that the movements will be stronger in both directions than the fundamental suggests. I argue that the result in this paper is not sufficient to prove that the population incorporate past prices in their valuation. Therefore, I suggest further research regarding the role of past prices. My result could be due to poor model specification.

7.4 FURTHER RESEARCH

The result from this paper suggest that elasticities are unstable. More research needs to be made regarding this finding. This paper argues that to find a better estimation of the elasticities one may need a longer time period. As Leonhard (2013) suggested, a cycle in the real estate market could last up till 22 years. This sample may therefore only cover around one and a half cycle. This could be insufficient amount of data to find the true elasticities and may be the cause to big difference between time periods and the structural break. By including more cycles one could capture several market climate and find the true effect.

This paper found an income elasticity above one as previous papers. I suggest that future research include more supply factors to see if this corrects the problem. Adding a real variable explaining the financial wealth of the household could improve this model. At last, the role of past pries could be further studied. This paper has found that past prices is an important factor when valuing the real estate market.

8. CONCLUSION

This paper found a small overvaluation of 0.96 percent in the Swedish real estate market. It has also shown that by using an autoregressive distributed lagged model one can model the fundamental values for real estate prices with both stationary and non-stationary variables. This result can serve as a further benchmark in model specification for the real-estate market. Further, the results indicate that the fundamental factors effect on real estate prices are unstable. The coefficients display a structural break and the elasticities are affected by switching time periods.

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