Does the price development on housing in Stockholm make sense?

An empirical analysis of a possible price bubble on the housing market of Stockholm

**Key words:** Toda Yamamoto approach, Granger-Causality, VAR model, Price bubbles, Swedish housing market

By: Rebecca Hedberg

Supervisor: Xiang Lin
Södertörn University | School of economics
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ABSTRACT
The indebtedness of Swedish households has more than doubled in the last ten decades despite the implementation of a mortgage ceiling and stricter amortization requirements (SCB, 2018). This study takes form to investigate how it is possible that debt related to housing is rising while new regulations against it has been set and how housing prices continues to increase when lending is supposed to be harder.

This analysis estimates whether there are indications of an existing price bubble in the housing market of Stockholm. It is done by testing fundamental economic factors to the price index of housing in Stockholm, to see if they support the price development.
If the analysis shows that housing prices cannot be predicted by the fundamental economic factors, it is possible that the price is a self-running series\(^1\) which could be an indicator of a price bubble. If fundamental factors that are being used as control variables seem to follow the same trend as the price development of the housing market, the speculation of price bubble will be rejected.

SUMMARY
The method used is the Toda Yamamoto approach with Stata (time series) in order to test for Granger-causality. If Granger-causality is firmly rejected, it is a sign that housing price is unpredictable and it could be indications of a price bubble.

The analysis shows a significant result of the variables that have been considered. It concludes there are sufficient evidence that housing price can be explained/predicted by the variables selected, meaning that the developments in housing price cannot be explained by a housing bubble.

1 If a variable is a self-running series, it means that other variables cannot predict the development in that variable. Hence, it “runs free”.

SAMMANFATTNING
Denna uppsats använder sig av Toda Yamamotos metod där tidsserier beräknas via det statistiska programmet STATA, i uppgift att upptäcka indikationer av en prisbubbla i Stockholm. Målet är att testa kausaliteten mellan utvalda ekonomiska variabler och det prisindex som visar utvecklingen av Stockholms bostadspriser.
Denna analys visar ett signifikant resultat, vilket innebär att det finns bevis att bostadspriserna stöds av andra ekonomiska variabler. Detta resulterar i att vi avvisar teorin om att det skulle finnas en nuvarande prisbubbla i Stockholms bostadsmarknad.

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\(^1\) If a variable is a self-running series, it means that other variables cannot predict the development in that variable. Hence, it “runs free”.
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**Introduction**

This chapter presents the underlying factors that contributed to the decision to implement a mortgage ceiling and harder restrictions of amortizing. It also discusses price development and highlights eventual problems with a price increase.

**1.1 Background**

On October 1st 2010, the Swedish financial supervisory authority (short name FI in this thesis from the Swedish name Finansinspektionen) introduced a mortgage ceiling in order to decrease the amounts of debts for households (FI, 2018). The mortgage ceiling concludes that new loans taken by individuals who uses housing as a security should not exceed 85 percent of the total value of the estate (FI, 2018). This regulation was set in motion in order to counteract an unhealthy housing market where banks could accept lending applications from consumers with high debt-to-income ratio (FI, 2017).

Later, on the 1st of June 2016, the FI also implied stricter amortization requirements which means that anyone who buys new real estate after this date is obligated to amortize 1 or 2 percent of the total value of the home annually, depending on the loan-to-value ratio (Regeringen, 2016).

Statistics showed that in 2018 the indebtedness of households were still high, leading to an additional amortization requirement being implemented within the same year. New homeowners were now obligated to amortize at least one additional percentage annually if the loan amount is larger than 4.5 times the annual gross income (FI, 2018).

The background reasoning that leads to the implementation of the mortgage ceiling is that household debt and loan-to-value ratios in Sweden has increased rapidly since the mid-1990s. Before the mortgage ceiling was set, there was no earlier regulation that decided how much debt a household was allowed to accumulate. Due to the deregulation in the mid-1980s, banks could govern their own lending (Riksbanken, 2019). During and after the financial crisis of 2008, there were concerns that banks and other credit institutions used higher loan-to-value ratios as a means of competition, which led to an increase in lending to households even if the economy was found in a recession (C. Goodhart and J.C Rochet, 2010).

**1.2 The purpose of stricter regulations**

The idea of implementing a regulation is to increase incentives for a higher safety-buffer and encourage households to borrow less (FI, 2017). Holding too much debt and a high loan-to-value ratio comes with a risk for the borrower since it creates a vulnerable situation in case of
a price fall on the real estate market. The borrower risks to retain a residual debt if it comes to a situation where the property has to be sold (FI, 2017). The purpose with the mortgage ceiling is to diminish the debt-to-value ratio among individuals by letting them borrow no more than 85% of the total value of the house (FI, 2017). When housing prices increases rapidly, there is a risk of individuals taking unsecured loans to finance the rest of the 15% instead of financing it by cash (SVT, 2017). Since unsecured loans in general have higher interest rates than top loans, individuals could be facing higher interest costs than they did before the implementation (SVT, 2017).

The new stricter amortization requirements are implemented with the purpose of helping individuals to not be over-indebted. The requirements mean that new mortgage borrowers who borrow 4,5 times their gross income before tax or more, must repay one percentage point more of the mortgage per year compared to the first repayment requirement (FI, 2017). The stricter amortization requirements go hand in hand with the mortgage ceiling where the aggregated purpose is to make sure that mortgage borrowers will be safe (or safer) in a situation of a price fall or increased interest rates (FI, 2017).

1.3 Aims of the thesis
The purpose of this analysis is to estimate whether there are indications of a price bubble in the housing market of Stockholm. This is done by analysing if stricter requirements have an effect on the debt-to-value ratio of homeowners in Stockholm and the aim is to test for Granger-causality in order to discover indications of a price bubble. The method used is the Toda Yamamoto approach where a Dickey-Fuller test is provided to test for unit root. If the p-exceeds the critical value, it concludes that the independent variable does not show a statistically significant relationship with the dependent variable and therefore the null hypothesis will be accepted. All data is quarterly based and selected between the first quarter of 2007 to the last quarter of 2020, making total observation; n = 56.

The main idea behind this paper is to:

- Understand if stricter regulations will lead to a lower debt-to-value ratio among new homeowners and if this leads to an effect on the housing prices in Stockholm
- Make a forecast for the future price development
- Analyse social effects that are being reflected in the price
Find out if the housing prices of Stockholm lies above its real value by looking at variables that should have a parallel or similar trend as the price development of housing.

Earlier studies show there are no uniform model when studying house prices and discovering price bubble could therefore be difficult. Birch Sørensen (2013) shows that the housing prices in Sweden lies above its fundamental levels, such as rents, disposable income and total supply. Case & Shiller (2004) argues that income growth could explain why housing prices can be set so high and Duca et.al., (2011) finds out that a mortgage ceiling could be an effective solution to cool off a heated market. None of the studies can find evidence of an existing housing bubble.

This thesis contributes to earlier studies with adding Toda Yamamoto approach in order to investigate if historical values of chosen economical variables have an effect on the development in housing prices of Stockholm. Earlier studies have focused on Sweden as a whole country, while this study focus on Stockholm specifically. Housing prices in Stockholm stands out due to its high prices and the goal of this thesis is to find out if the price development make sense.

The expectation is that the chosen independent variables can explain the development in housing prices. Average income is expected to follow a similar trend as the price index of housing in Stockholm. A higher average income could explain how people can afford to buy at high prices.

Since bubbles cannot fully be identified before they burst, the aim in this thesis is not to identify a current housing bubble, but to find indications that a bubble might exist. If historical values of the independent variables cannot predict the development in the housing prices, there is a possibility that the real estate market of Stockholm might find itself in a price bubble.
2. The housing market
This chapter represents some important policies and fundamentals that affect the housing market and can help us explain the price increase. Some statistics will be discussed and analysed in order to investigate if it is an on-going bubble in the housing market of Stockholm.

2.1 Housing market of Stockholm
There is an ongoing consideration regarding the development of the Swedish housing market among many macroeconomics today. This is mainly because of the sharply rising house prices that in turn also could be a factor of increased indebtedness of the Swedish households (European commission, 2016), (Birch Sorensen, 2013).

The price of housing in Stockholm are currently at an all-time-high level and according to Ekonomifokus (2021) there are signs of a further increase. When prices are constantly rising, first-time buyers and households with lower income face harder barriers to enter the housing market and the mortgage ceiling may have caused longer saving periods in order to achieve a down payment. Maximum lending or unsecured loans could be the solution in those situations (SVT, 2017).

The expectations of a continuously growth has been accurate for a long time. Although, since there are expectations of a rise in the interest rate in near future, the expectations of the market can be changed. In a longer period, there have been low interest rates in Sweden, making housing more affordable. The expectations are that the market will react negatively if the discussions of higher interest rate would become reality (Ekonomifokus, 2021).

The FI found out that an increase in the interest rate by five percent from today’s level would cause that six percent of the whole population would run an economic default, according to performed stress tests on the Swedish mortgage market (FI, 2018). More than 65 percent of the population in Sweden today own houses with a loan-ratio of 90 percent and as the property tends to increase in its value, homeowners tend to increase their loaning from private banks (FI, 2018).

If the price index per capital increases more than the real income does, then it could cause consumers spending more money on their housing and less money on other goods, which will have a negative effect on the economic growth for Sweden as whole (FI, 2018).
2.2 The lending market
The Swedish population has increased its private risk by twice as much of their real income on mortgages since the mid 1990’s and the lending ratio has increased by over 100% (Eurostat, 2014). Evidence shows that debt has increased more than income since the 1990’s (Ekonomifakta, 2020). If the development continues, the loaning ratio per capita will expand and consumers will be more vulnerable to changes in the economy, e.g. if the interest rate would rise.

The lending-capital ratio has continued to increase even though the lending-factor was crucial during the financial crisis of 2008. The crisis occurred when one of the major investment banks in the world collapsed, the bankruptcy of Lehman Brothers in the US.

The event of Lehman Brothers caused a global effect and the main reason why the bank collapsed, in short terms, was due to falling housing prices and the high lending-ratio to people that should never been accepted a loan to begin with (SVT, 2018). Investment banks collected payment streams of mortgages and packaged them into one unit to create a type of asset-backed security, so-called Collateralized Debt Obligation (CDO’s) in order to sell them as investments to other institutes (Bates Group LLC, 2012). Later, when mortgages could not be paid, these investments fell as dominos which affected investors, banks- and consumers (SVT, 2018).

Despite the learnings from the financial crisis of 2008 and even though the Swedish government have implied new rules of lending in order to prevent consumers from indebtedness, the lending-capital ratio has continued to grow (FI, 2018).

The mortgage market has regulations that banks need to take in considerations when accepting loans to individuals. The market is mainly based on loaned money and the lending policies of banks depend on the expected ability of lenders to repay their debt (FI, 2018). The FI has decided that mortgage receiver needs to pay at least 15% of the total value of the property in cash, but total income of the household is also a parameter that matters since the total loan should not exceed 4,5 times the total income of the household (FI, 2018). The mortgage receiver also needs to sign an amortization plan for how long you tend to have the money loaned from the bank (Regeringen, 2016).
2.3 GDP & the average income level
The GDP level is a measurement that tells us in what stage of the market a country currently is and can therefore explain the development on the price index variable. An increase in GDP equals a rise in prices, therefore is average income level a proxy for GDP in this thesis.

An increase in the average income level yields a higher purchasing power which in turn will have a positive effect on the price index variable. Also, an increase in the average mortgage payments can be captured by the disposable income level as well. When prices rise, income will increase, meaning that GDP level and price index should go hand in hand.

There is a positive relationship between income level and housing prices, implying that it is expected that housing prices should be more expensive in districts where income level is high (Brown, 1980). The relationship says that if housing prices continue to increase, income should increase too. Hence, the GDP level should increase as well.

Since the inflation target of the Central bank is to reach a two percent increase yearly, an increased price level is expected and not a necessarily hint of something being wrong (Riksbanken, 2018). If average income is increasing, the natural consequence is that the price level is increasing as well since higher income yields a higher purchasing power. When demand goes up, price goes up as well (C. Öner, 2020).

2.4 Interest rates
We cannot predict if a boom in the housing market will be followed by a bust, neither that we can predict if a bust must be triggered by a boom. What we can predict is that a bust is possible to arrive after a period of increasing housing prices. In most cases, a bust occurs when there is a considerable negative change in the GDP growth (Helblling, 2003).

One of the main tasks regarding the interest rate for the central bank to handle is to adjust for macroeconomic effects in order to control and maintain a stable inflation rate (Riksbanken, 2018).

The central bank can adjust the interest rate to keep the consumption level and price development stable. This is an effective tool when the economy is facing cycles as recessions and booms (Riksbanken, 2018). A low interest rate will boost both net profits and net income which will push up prices of housing. While high interest rate has the opposite effect (Bank of Australia, 2016).
As the central bank changes their interest rate, private banks tend to follow. Besides the interest rate, there is a repo rent which is an interest rate that affects all banks that are lending or investing their money in the central bank (Riksbanken, 2021). The central bank of Sweden has lowered the repo rent to a historically low level in order to simulate demand and to rise inflation (Riksbanken, 2021). The mortgage rent is directly affected by the repo rent; when the repo rent is risen the mortgage rent for the households will increase, which can give long-term consequences for the loan lender.

Sweden has faced negative repo rents in the recent years, which gives housing prices an opportunity to continue to rise and for individuals to buy at higher prices (Riksbanken, 2014). Consumers tend to invest more and save less in these situations, which could cause a problem in case of a price fall or increased repo rents (Ekonomifakta, 2021, 2).

2.5 Housing as an investment

Housing assets are in general a large purchase and cost of a household and is therefore often made as a long-term investment, meaning that the buyers will own the property for a longer period comparing to other goods.

Real estate can be regarded as a non-consumable asset and an investment since people tend to live in their property for a longer period and the cost of owning is possible interest rate costs for mortgages (Stiglitz, 2012). The value of the property is affected by macroeconomic parameters such as the current economic situation with inflation, interest rates, taxation rate, mortgage costs and the nearby supply (Andersson, 2014). The housing market tend to attract more people to larger cities where there is a greater possibility of finding a job, which causes the demand of housing to go up and prices to rise (Andersson, 2014).

There has been a positive trend in the price development in housing for decades, which could create a belief that buying a property is a safe investment in long term. It is a common belief in larger cities like Stockholm that if you are not making a profit of your property, you will at least get your invested money back when selling. This belief could have an impact on individuals when buying an expensive property since it is believed to be almost a risk-free investment and it could therefore also be an explanation to why people continue to buy at high prices (Stiglitz, 1990)

The real estate market is a unique investment since the price between two similar objects can vary a lot. Even if two apartments are being sold in the same building at the same time, the
price can differ since each object is unique (Andersson, 2014). Therefore, it is objectified to say that the housing market is dealing with monopolistic advantages. The first competition is the close neighbourhood, then the different parts of the municipal and later municipal versus other municipals (Stiglitz, 2012).

2.5.1 Why the housing market continue to increase
A rise in income, changes in the taxing system or the interest rate, the unemployment rate or demographic reasons are all variables that have an effect on the housing market (Ekonomifakta, 2021). The central bank of Sweden concludes that the large increase in housing prices can be derived into fundamental aspects as people continuously move to larger cities. A positive development in housing prices of Stockholm can be expected since it is the capital of Sweden. Growth in population will naturally yield an increase in demand of housing (C.H Mulder, 2006).

Figure 1. The price development on apartments in Stockholm between years 1996 - 2020

The graph shows square metre price on the y-axis based on SEK and years on the x-axis
Source: Svensk Mäklarstatistik (2021)

When demand of housing is high, it requires a high producing level of new constructions to keep supply on the same paste. When supply of housing does not grow as fast as demand, competition of housing will result in prices being pushed. When prices surpluses the efficient price equilibrium level, the market could be set as inefficient (Birch Sorensen, 2013).

2.5.2 Effects of the price increase
A rapid price development on the housing market can cause a large effect for the economy as whole since higher prices could cause higher debt-to-value ratio among new property owners (FI, 2020). When prices are high, people tend to consume more since increased prices means
that the wealth of the household is growing which can be interpreted as greater consumption space (FI, 2020). This also affects old property owners since rising house prices increases lending space to households as the value of their collateral for loans rises. If the house prices would fall, the effect will behave in reverse with reduced consumption and a reduction in economic growth (FI, 2020).

A price fall could cause that the value on debts would surplus the value of the housing. It could also cause a risk of households not being able to pay their mortgages (FI, 2020). If a situation like this would occur it would not only affect households but also banks and credit institutes. If the loss would appear big, it is a possibility that it could be a threat for the stability of the whole financial system (Ekonomifakta, 2021).

It does not necessarily imply a problem with an increased real price level. If real income would increase with the same proportion, then the consequence of a higher price level would only be expected (C. Öner, 2020).

3. Theory

This chapter contains a discussion of the current price development in the Swedish housing market. It captures previous research and theories of the mortgage market and a macroeconomic aspect of price fall in the real estate market that both leads up to a discussion about the phenomena of price bubbles.

3.1 The market theory
In order to have an existing market it is obligated to have supply that is met by demand. It is usually visualised by a graph where the supply curve has a positive slope that is met by the demand curve with a negative one. The demand is controlled by the purchase of the consumers and is driven by different causes (Shiller, 2007). The market theory can be applied to the housing market but differs from many other markets since it moves sticky. The demand can vary a lot in short run while the supply is more or less the same since it requires new buildings being built to increase the supply of the market. Therefore, the price change in short run should go hand in hand with the consumers’ demand (Shiller, 2007).
Figure 2. Graph of demand and supply in the market

![Graph of demand and supply in the market](image.png)

*Source: The graph has been created by the author and is inspired by Birch Sorensen (2013) who shows shifts in long-run supply and demand*

The graph above illustrates how price gets affected when shocks in demand happens. The S-curve represents supply, the D-curve is market demand and the y-axis shows price and x-axis quantity. When demand rises, the curve get pushed upwards and prices will increase (moving from \( q \) to \( q' \) and \( p \) to \( p' \)).

The price level of the housing market could be changed when a significant event happens that shifts the demand curve. A significant event could be a positive change in real income or even the expectation of a change in the future. It could also be a rise in financial assets, lower taxes, changes in mortgage rates or speculations of a rise in the price level (Shiller, 2007). The last event mentioned is being explained in the next chapter called The Greater Fool Theory.

### 3.2 The greater fool theory

The Greater Fool Theory explains why a buyer is willing to pay a higher price than the asset is worth at the purchasing moment. It says that the buyer agrees to the higher price because there is hope to sell it in the future for an even higher price and make a profit of it (Segerborg, 2010).

The theory can be applied to the housing market since individuals who buy property at a higher price than the property is worth is based on the expectation that the price of the asset will continue to rise. This expectation is what drives the individual’s willingness to pay, and it comes from the fact that the market price on housing have been rising continuously for the last decades. An individual who pays a price that lies above the market value in belief of
selling it to an even higher price, believes that he or she has made a profit from his folly. This means that the consumer buys to a higher price in hope that an even bigger fool will later buy for a price even higher (Segerborg, 2010). This drives the prices of the housing market in a positive development.

According to the theory, in so called fooling periods it is a positive correlation between previous price changes and long-term positive price changes that lies over the median value for the test period. The theory can be interpreted as the expectations that has been assumed of the price from the previous period that can lead to prices in the housing market being driven up fast and causing the market to end up in a price bubble.

3.3 Price bubbles theory
Since housing prices has increased rapidly the recent years, the theory of this thesis is based on the assumption of individuals using housing as an investment. The concept of rational bubbles will be in focus and behavioural models will be discussed. Rational bubbles can be observed when there is a speculation of price increase in the future and where individuals are willing to pay a price that exceeds the fundamental value in belief that prices will continue to rise (Stiglitz, 1990).

3.3.1 The definition of a price bubble
We can get a hint whether an asset finds itself in a price bubble or not by investigating if the price lies above its “normal” market value for a longer period of time (Lind, 2009). Although, finding the normal value of an asset is difficult since there is no clear definition of what a fundamental value is. According to Lind (2009) a bubble should be defined as a rapid increase followed by an equivalently rapid decrease in value, where the time between the increase and decrease should be no longer than two years. When it occurs between longer periods, Lind (2009) says that it can be expected that the bubble was influenced by different factors and also bust by different reasons.

A bubble can increase due to psychological effects. If housing prices continue to increase, people might think it is a risk-free investment since the increase seems to go on forever and they will hurry to buy a property quickly before it gets more expensive. When the common belief is that prices can only go up, the demand of new housings will increase. As soon as the prices cease to increase, the demand will take a downturn and prices will start to decline and the bubble is therefore expected to burst (Shiller & Case, 2004).
3.3.2 Causes of a price bubble

Price bubbles arises for different reasons and can vary between markets and it is therefore hard to find a single indicator that can be used to prevent all the markets from price bubble formations. Instead, it is necessary to use a set of indicators that can be used depending on what kind of adjustment the market needs (Lind, 2009).

Governments and the central bank can use different tools in order to adjust their policies in time in order to avoid bubble formations (Andersson, Claussen et.al., 2011). To know which tool is regarded, information about psychological factors like the motivation of the buyer is necessary to complete the analysis (Shiller & Case, 2004).

It is a common phenomenon that bubbles starts its formation when the economy is in a boom. Macroeconomic factors such as low interest rates, high employment rate and high incomes are all factors that drives the demand in the market (Lind, 2009). Although, the formation of price bubbles are a complex phenomenon that could depend on the interaction on several factors and is therefore difficult to point out exactly what causeed what (Kubicova & Komarek, 2011).

The expectation of the buyer is important, but cannot fully explain the emergence of the formation. According to the Corporate Finance Institute of Sweden, there are three specific indicators that are the most important criterias for price bubbles to arise (CFI, 2021).

- The first criteria is low interest rates, since it makes it easier for people to get a cheap credit. This allows individuals to spend more money which in turn results in rising prices due to increased demand for goods.

- The second criteria is the demand-pull inflation, that says that prices for assets intends to increase when the demand goes up. The increase in prices is seen as an indicator of future increases in price which leads to formation of a speculative bubble.

- The third criteria is the supply shortage, which means that an increased demand for an asset comes from a reduced supply or the expectation of a reduction in the supply of an asset in the future. If there is limited number of assets avalible in the market, there is a tendency that investors rush to buy as much as possible.
3.3.3 Finding price bubbles

To investigate whether there is a possibility of an existing housing bubble, there is some signs that we can base our assumption on. First, there is some signs that could tell us whether we could be in the middle of a bubble formation. The first one is whether the rise in housing prices deviates from the standard rate. A major sign of housing bubble is fast-rising house prices. Other signs could be if there are many risky mortgages in the market and if most loans issued require mortgage insurance. The last sign is if there is rising interest rates (FI, 2020).

To evaluate if housing prices deviates from the standard rate, the finance-based approach is to calculate the fundamental value of housing as an investment by discounting its future expected earnings (Jia & Li, 2014). This approach aims to identify a possible bubble by comparing price of housing to other fundamental values, like the long-term average income, that could tell whether the housing price seems to be overvalued or not (Bourassa, Hoesli, & Oikarinen, 2016). If the compared fundamental values seem to exceed the value of housing prices, then there could be indications of a bubble.

This thesis bases its assumption that individuals are seeing housing as an investment, which gives support for the theory of speculative bubbles. In equation (1) below, let \( p^f_t \) be the assumption that consists of a market fundamental term and let \( B_t \) be the bubble term that represents the deviation of the current market price.

\[
p_t = p^f_t + B_t \quad (1)
\]

The equation can be used with different price tiers; when market prices of housing are low (L), medium (M) or high (H). Measurement between the different price tiers is made with equation (2) below.

\[
y_{ij}^t = p_{i,t} - p_{j,t} = (p_{i,t}^f + B_{i,t}) - (p_{j,t}^f + B_{j,t}) \quad (2) \quad \text{for } i, j = L, M, H \text{ and } i \neq j
\]

Now when different price tiers can be compared, the next step is to test whether they follow a nonzero mean process or not. The price sequences must be cointegrated with cointegrating vector \([-1, 1]\).

\[
Y_{k\to\infty} E_t (p_{i,t+k} - p_{j,t+k} | 1_t) = \beta_0 + \beta_1 t \quad (3) \quad \text{for } i, j = L, M, H \text{ and } i \neq j
\]

Where \( 1_t \) denotes the information set at time \( t \).

The convergence to stationarity in long-term can only differ by \( \beta_0 + \beta_1 t \) at a finite fixed time
Shocks in the economy that can affect housing prices should be temporary and short-term based.

A problem with investigating price tires in order to detect a bubble is if both periods appreciate at similar rates. In those situations, it is hard to distinguish whether there is an overvalued market or not. Another issue is if a structural break in the difference of the price tiers is discovered and the conclusion is being made that the break could indicate on a price bubble, when in fact the break is due to an asymmetric reaction of the tiers to market fundamentals that is not related to a bubble.

4. Previous studies

This chapter represents previous studies that brings up important fundamental factors that explains the housing market. Chapter 4.1 – 4.1.3 represents findings from three different studies that touches the same subjects that are being investigated in this thesis and a summary of them all is represented as last.

4.1 Birch Sørensen (2013) The Swedish Housing Market: Trends and Risks
Birch Sørensen (2013) published a report in the Swedish institute of finance about the housing prices of Sweden. The report showed that real prices were at a historically high level and since the release of this report, housing prices has continued to increase. Sørensen (2013) tells us that the increasing trend in real price of housing does not only apply to Sweden but to several OECD countries as well.

To investigate whether the Swedish housing market is overvalued or not, Sørensen evaluates the fundamental price level in the housing market and compare it to the actual price level in long-run equilibrium. Sørensen describes fundamental house prices as “the equilibrium house price that would prevail if households had rational expectations about the fundamental variables which determine the future value of the housing service delivered by their house”. Fundamental variables could be set as the future levels of income, interest rates and rents, which all have an impact on housing prices.

The expectation is that actual house prices should deviate from fundamental ones, partially because consumers may not always have realistic expectations about the future fundamentals determining future house values. By estimating a vector error correction model (VEM),
Sørensen investigates whether actual house prices tend to move towards the fundamental level.

\[
\Delta P_t^a = \alpha_1 (p_t^a - p_t) + \mu_{11} \Delta p_{t-1}^a + \mu_{12} \Delta p_{t-2}^a + \cdots + \mu_{1n-1} \Delta p_{t-n+1}^a + n_{11} \Delta p_{t-1} + n_{12} \Delta p_{t-2} + \cdots + n_{1n-1} \Delta p_{t-n+1} + \epsilon_{1t} \quad (1)
\]

\[
\Delta p_t = \alpha_2 (p_t^a + \beta p_t) + \mu_{21} \Delta p_{t-1}^a + \mu_{22} \Delta p_{t-2}^a + \cdots + \mu_{2n-1} \Delta p_{t-n+1}^a + n_{21} \Delta p_{t-1} + n_{22} \Delta p_{t-2} + \cdots + n_{2n-1} \Delta p_{t-n+1} + \epsilon_{2t} \quad (2)
\]

Where:

- \(P_t^a\) = The logarithm of the actual real house price in quarter \(t\)
- \(P_t\) = The logarithm of the estimated fundamental real house price in that quarter
- \(\Delta\) = Indicates a change in the variable of the previous quarter to the current one
- \(\alpha\) = Actual house price
- \(\beta\) = Fundamental house price

Parameter \(\beta\) is expected to be equal to minus 1 and \(\alpha\) should be significantly negative if actual house prices tend to converge on fundamental house prices.

If actual house prices exceed the fundamental house price, there is a risk that real house prices would fall, hence \(\alpha_1 < 0\):

\[
\Delta p_t^a = \alpha_1 (p_t^a - p_t) + \mu_{11} \Delta p_{t-1}^a + \mu_{12} \Delta p_{t-2}^a + \cdots + \mu_{1n-1} \Delta p_{t-n+1}^a + n_{11} \Delta p_{t-1} + n_{12} \Delta p_{t-2} + \cdots + n_{1n-1} \Delta p_{t-n+1} + \epsilon_{1t}, \quad \alpha_1 < 0 \quad (3)
\]

Data shows that the housing prices in Sweden lies above the fundamental levels, such as rents, disposable income and total supply. Empirical analysis indicates that actual housing prices moves towards the fundamental price level.

Although, Sørensen finds it difficult to state whether the housing market is overvalued or not, since fundamental factors shows different results in his study. His empirical house model estimates that rents to rents and incomes do not indicate that Swedish house prices are overvalued to any significant degree.
4.1.2 Case & Shiller (2004) Is there a bubble in the housing market?

Case & Shiller use quarterly based data from an almost twenty-year period between 1985 – 2002 to investigate whether the boom in housing prices that occurred 2003 in the US could be a bubble and if there was a possible burst or deflate that was waiting in front of them.

In the first stage, they used state-level data on house prices and different fundamentals and performed a log-linear reduced form regression with following dependent variables; The level of home prices, the price-to-income ratio and the quarter-to-quarter change in home prices. While the explanatory factors were; Income per capita, population, employment, unemployment rate, average mortgage and interest rate.

Their data showed that income growth could explain why the housing prices was being so high in most states. In some of the states, Case and Shiller could see patterns of declining price-to-income ratios even though housing prices continued to rise. Therefore, they argued that the hypothesis of an existing bubble in those states could not be rejected.

In the second state of investigation, Case and Shiller conducted a survey where they asked 2000 people who had bought a property in 2002 between March and August from four different areas; Los Angeles, Boston, San Francisco and Milwaukee. Their main idea of the survey was to investigate people’s expectations of the by asking about the thoughts and theories behind the possible future price increase, the risk of falling prices and worries about being priced out if they did not hurry to buy now. When collecting the answers, they focused on following seven criterions in order to make a conclusion.

1. Widespread expectations of an increase in house prices
2. Housing prices increase more than private income
3. House prices receive much attention in the media and private conversations
4. A widespread comprehension that is profitable to own housing
5. Simplified opinions regarding mechanics of the housing market dominates
6. Limited understanding of the risk attached to the investment
7. People are pressured to become home owners

Their conclusion from the survey was that there are indications of bubbles, especially when looking at the high expectations of future price increase and the strong word-to-mouth spreading among individuals. Although, combining the survey with the econometric analysis, Case and Shiller found little evidence of an existing housing bubble.
4.1.3 Duca et.al., (2011) House Prices and Credit Constraints: Making Sense of the US Experience


The authors find out that in a price-to-rent framework, the relationship between the loan-to-value ratio of first-time buyers and the price-to-rent ratio shows that credit standards for first-time-buyers significantly affect house prices. By adjusting the loan-to-value ratio for first time buyers, hence lowering the size of mortgage standards, the effective demand of housing raised. Tightening the mortgage standards in the US did affect potential marginal home-buyers which contributed to a steamed market.

If the ceiling was reduced by 1 percent for first time-buyers in the US, their data showed that the prices of the housing would decrease by the same amount in long-term. Crowe et.al., (2011) confirms the same result after doing a cross-sectional data of 21 countries. Their calculation shows that a decrease of the mortgage ceiling by 1 percentage will result in a nominal value of 1.3 percentage lower housing prices than before the regulation. The conclusion is that asset bubbles are linked to an unsustainable easing of credit standards and therefore, a mortgage ceiling could be an effective solution to cool off a heated market.

4.1.4 Summary of earlier studies

Earlier studies show there are no uniform model when studying house prices and discovering price bubble could therefore be difficult. There are different solutions when investigating housing prices; Some have a theory that actual prices versus fundamental prices should be compared, while some prefer to compare actual price to the expected value set by individuals.

Birch Sørensen (2013) shows that the housing prices in Sweden lies above its fundamental levels, such as rents, disposable income and total supply. Empirical analysis indicates that actual housing prices moves towards the fundamental price level.

Case & Shiller (2004) argues that income growth could explain why the housing can be set so high. Indications of a bubble could be a fact when looking at fundamental values, but the
expectations of individuals told the opposite. Therefore, they did not find enough evidence of an existing price bubble.

Duca et.al., (2011) finds out that mortgage ceiling could be an effective solution to cool off a heated market.

5. Empirical analysis

This part describes the variables used to analyse the price development on housing in Stockholm. This thesis will base its fundamental values and statistical method on the summary from earlier studies in order to reach a conclusion of a price bubble.

5.1 Data description

Data is chosen based on the previous research and from the theory behind the housing market. The price index of housing in Stockholm is set as the dependent variable and will be tested against independent fundamentals that is believed to influence the price. 

All data is expressed as quarterly and covers the first quarter in 2007 to the last quarter in 2020 with a total of 56 observation.

The dependent variable - Price index variable

Data is collected from the Valueguard-KTH Housing index (HOX) which is a quality-adjusted price index for housing in Sweden that shows the price development for housing in Stockholm. The index is based on data provided by Swedish broker statistics and the cadastral survey and has been developed in collaboration with KTH and distributed by Nasdaq.

Gross domestic product (GDP)

The Gross domestic product (GDP) variable is represented as a proxy for the average income level since salary and profit share is calculated as a share of GDP (LO, 2018). Changes in GDP and average income can be expected to correlate since income should rise if the price level in a country goes up (Andersson, Claussen et.al., 2011). The variable is chosen due to earlier studies made by Birch Sørensen (2013).

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KTH is a short name for Kungliga Tekniska Högskolan (The Royal Institute of Technology) which is a state-owned Swedish university in Stockholm with a main focus on technology and science.
**The barometer indicator**

The barometer is exogenous and an indicator of the current economic situation in Sweden based on surveys where households and companies have answered to questions about the current situation and expectations of the future prospects in the economy (Ekonomifakta, 2021,1). What to be found, the barometer indicator has not been included in earlier studies, thus it is an important variable in this thesis since speculative bubbles are in focus and individuals tend to invest more if the expectation of the market is positive. The barometer take inflation in advance and spots economic fluctuations during the years.

**The repo rent**

The repo rent is included since the study of Birch Sørensen (2013) tells that low interest rate will boost both net profits and net income, which will push up housing prices. While high interest rate has the opposite effect (Bank of Australia, 2016).

**Population**

The variable of population in Stockholm is added as a control variable that is included since the central bank says that an increased population could be an explanation of the large increase in housing prices (Flam, 2014). Case & Shiller (2004) does include the population variable in their regression since if population is risen, competition of housing will rise which in turn push up prices. If population is low, supply of housing will exceed demand and prices will fall (SCB population, 2014).

**Debt-to-income**

Due to earlier studies of Case & Shiller (2004), the average debt-to-income ratio is an important variable to include since it is a measurement that shows debt in relation to average disposable income of a household. A high household debt could indicate an economic instability if housing prices would decline. Therefore, it is a crucial variable to include when wanting to make sense of the housing market (Amundsen, 2013).

**Lending to households (MFI)**

The variable represents the total average lending of monetary financial institutions (MFI) to Swedish households at a quarterly based growth rate. Since the introduction of stricter regulations, lending to households is supposed to be stricter. The ratio between average disposable income and loans should not change over time. If lending increases above the long-term average position, there is indications of that the market may be overvalued (Finocchinaro et.al., 2011).
The mortgage market

The data of the mortgage market shows the average interest rates of the mortgages in Sweden by the end of each quarter. Since the interest rate is the same for the whole country, it can be applied when looking into Stockholm specifically. Case & Shiller (2004) includes the variable in their report as an explanatory variable and therefore it is set as an independent variable in this thesis that might can explain the development in the dependent variable.

Consumer Price Index (CPI)

The consumer price index (CPI) is an index that measures the average price development for the entire private domestic consumption in a country and shows what the consumer actually pays. The changes in the CPI from previous period to current is what we call the inflation rate (SCB, 2021). The variable is included due to findings of Shiller (2007) who describes factors that has an effect of the demand curve. When inflation is high, prices on goods goes up, which in turn lower the purchasing power as individuals can afford less consumption. Inflation can occur due to different reasons, but an increased demand is one cause.

5.2 Expectations

Since bubbles cannot fully be identified before they burst, the aim in this thesis is not to identify a current housing bubble, but to find indications that a bubble might exist. Having a place to live at is a necessity for individuals in a society. Therefore, we cannot expect the housing market to follow the basic economical concepts, nor we can expect a perfect parallel trend to other variables (Birch Sorensen, 2013).

The expectations of the empirical estimations are based on macroeconomic theory of how fundamental values should react to changes in the economy. The anticipation is that fundamental factors can explain the price development of housing in Stockholm. The price index variable is expected to react positively by a decrease in interest rate since low interest rates yield less expensive mortgages and hence, a richer property budget. Likewise, should an increase in both GDP level and CPI create a higher purchasing power for individuals since a rise in those variables should be related to higher incomes.

The population variable is expected to have a positive effect on the price index variable. When population is increasing, the demand for housing will increase too. When there is competition of housing, prices will be pushed up.
The mortgage ceiling was implemented in order to lower the debt-to-income ratio among the population, which is the individual’s ability to repay their debt. The belief of debt-to-income ratio and lending to households is that they will develop a weak negative trend against the price index variable since mortgages shall not exceed 85% of total purchase and the total amount borrowed cannot exceed 4,5 times of total cost. If income rise, individuals do not have to borrow as much money from the bank to purchase housing. Although, the ceiling may also cause an effect on the demand for other loans, such as unsecured loans. Those types of loans have in general much higher interest rates and is easier for individuals to be accepted since they come from private investment institutes that has different rules to regulations than regular banks have (SVD, 2020).

6. Method

This chapter tells the expectation for the estimation and describes the method used for the empirical analysis of this thesis and shows what data are set and which variables that is being used in the model. The chapter also bring up the limitations of the thesis and the divisions used in the empirical models.

6.1 Testing for stationarity

A variable is defined as stationary if its probability distribution does not vary over time, meaning that its mean, variance and autocorrelation does not move randomly (Stock and Watson, 2015 s. 586-587). Stationarity is being tested through the Augmented Dickey-Fuller (ADF) test, which depends on the feature of underlying time series, such as random walk, deterministic trend and model with drift (Stock and Watson, 2015 s. 602-606).

The test of stationarity is based on the concept of Dolado et.al., (1990) that uses a three-stage to see if the variables is significant or not. If null hypothesis can be rejected in this first stage, there is no need to continue. The procedure will otherwise continue to the second and the third step where the model will, respectively, be applied to the model with drift or the model with neither drift nor deterministic trend. If result shows non-stationarity, then testing will move forward for difference stationarity.

The GDP variable in this thesis is set as a proxy of the average income that is set as a fundamental component that defines whether the price increase on housing make since or not. By looking at the GDP we can forecast if the price development on housing in Stockholm is expected to continue its increase. If the growth rate of the price variable has similar or parallel
trends with the GDP variable, the speculation of a bubble being present will be rejected. The assumption will be that housing prices are stationary, meaning there will be no changes in the probability distribution of the price index variable over time (Stock and Watson, 2015 s. 586-587).

6.1.2 Testing for explosive behaviour (non-stationarity)
If a time series has either a time-varying mean, time-varying variance or both, the time series is non-stationary and has a probability distribution that does vary over time (Hobdari, 2014). The changes in the distribution often relies to variables following a time trend or the dependeness to the development on other macroeconomic variables. Variables that are non-stationary can have time dependent variances and increase over time (unit root). Non-stationary data are unpredictable and cannot be forecasted. The variables can seem to be stationary as they can move in parallel trends over time, but it does not mean that the movement for one variable causes the parallel movement of the other one. If time trends are not taken into consideration when investigating variables, it is easy to falsely conclude that changes in one variable is caused by another when in reality they are not related. These types of regressions is called spurious regressions and can often be characterized with a high R-squared\(^3\) \((R^2)\) (Stock and Watson, 2015 s. 607-610). In order to receive consistent results, the non-stationary data needs to be transformed into stationary data.

According to Phillips et.al., (2105), bubbles have a non-proportional growth rate and therefore can be expressed as they are increasing explosively. The bubble growth is a part of the price system, meaning that the price variable will increase explosively as well. This thesis uses GDP as an explanatory variable that also can be observed as the fundamental component that can either make sense or no sense to the price increase. If the GDP variable does not grow at the same explosive rate as the price variable, there is a possibility that the price variable has exceeds its fundamental value and the conclusion can be that there is a tendency of existing price bubble.

6.2 Statistical model
This thesis uses two different statistical models in order to test for stationarity. The assumption of price bubbles being rational are present in both tests. The test being used is a Dickey-Fuller test, which is a unit root test (ADF) with Stata (time series). The aim is to test

\(^3\) The R-squared \((R^2)\) of a regression measure how well the OLS regression line fits the data. The higher the \(R^2\) is, the more it explains.
the null hypothesis in order to discover the presence of unit roots in an autoregressive time series model. The statistics in the Dickey-Fuller that is used in the ADF is a negative number and the more negative it is, the more it convinces us to reject the null hypothesis of an existing unit root.

6.2.1 The Dickey-Fuller unit root test

The intuition behind a unit root test is that it determines how strongly a time series is defined by a trend. Seven of nine variables are being set on a logarithmic scale and each time series will be tested for the presence of a unit root and their order of integration. The test will be conducted at 1, 5 and 10% significance level. When the test has been made, the result of the p-value will make inferences about the time series and tell us if it is stationary or not.

The Dickey-Fuller statistics that is being used is represented in equation (4) below.

\[ \Delta Y_t = \mu + \delta Y_{t-1} + u_t \]  (4)

Where:
\( \delta = (p - 1) \)
\( \Delta \) = the difference operator
\( u_t \) = white noise

In equation (1) we test that \( \delta = 0 \) for the null hypothesis.

If \( \delta = 0 \) then \( p = 1 \), meaning that we have a unit root and the time series can be defined as nonstationary.

The estimated t value of coefficient \( Y_{t-1} \) in equation (4) follows the tau (\( \tau \)) statistics under the null hypothesis where \( \delta = 0 \), which Dickey and Fuller have computed critical value for tau statistics on the basis of Monte Carlo simulation based on the assumptions of Gauss-Markov, which is a technique used to model the probability of different outcomes in a process that

\[ \text{Variables that are being set on a logarithmic scale are the exogenous ones; The price index variable, the GDP, population, average debt-to-income ratio, average lending to households, average mortgages and consumer price index. While the barometer indicator and the repo rent are not.} \]
cannot easily be predicted due to the intervention of random variables (Stock and Watson, 2015 pp. 224-227).

The Dickey-Fuller test can be performed in three different forms with three different hypotheses. The null hypotheses assumes that the true process is either a random walk (1), a random walk with drift (2) or a random walk with drift around a stochastic trend (3).

(1) $Y_t$ is random walk:
$$\Delta Y_t = \delta Y_{t-1} + u_t$$

(2) $Y_t$ is random walk with drift:
$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + u_t$$

(3) $Y_t$ is random walk with drift around a stochastic trend:
$$\Delta Y_t = \beta_1 + B_2t + \delta Y_{t-1} + u_t$$

Table 1. A summary of the Dickey-Fuller test in three different forms

<table>
<thead>
<tr>
<th>Form</th>
<th>Hypothesis</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random walk</td>
<td>No constant, no trend</td>
<td>$\Delta Y_t = \delta Y_{t-1} + u_t$</td>
</tr>
<tr>
<td>Random walk with no drift</td>
<td>Constant, no trend</td>
<td>$\Delta Y_t = \beta_1 + \delta Y_{t-1} + u_t$</td>
</tr>
<tr>
<td>Random walk with drift around a stochastic trend</td>
<td>Constant and trend</td>
<td>$\Delta Y_t = \beta_1 + B_2t + \delta Y_{t-1} + u_t$</td>
</tr>
</tbody>
</table>

A common factor for all forms is when the null hypothesis is zero ($\delta = 0$), the series have a unit root and nonstationary. If $\delta > 1$ the process is explosive and will increase over time.

In case there is autocorrelation in the dependent variable ($\Delta Y_t$) of the regression, $u_t$ will be autocorrelated as well. The ADF test is conducted by “augmenting” the preceding three equations by adding the lagged values of the dependent variable $\Delta Y_t$ to control for autocorrelations.
Equation with ADF test will then become:

\[
\Delta Y_t = \beta_1 + B_{2t} + \delta Y_{t-1} + \sum_{i=1}^{m} \Delta Y_{t-i} + u_t \quad (5)
\]

where \((m)\) = maximum lags. The test statistics will be calculated for each lag up to the maximum lag order, which can be zero.

By adding auto-regressive lags and a trend and still assuming null as \((\delta = 0)\), one can control for autocorrelation in the error. The choice of lag “n” depends on the frequency of data.

\[
\Delta Y_t = \mu + \delta Y_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta Y_{t-1} + u_t \quad (6)
\]

The Dickey Fuller unit root test is a one-sided test that focuses on the 1, 5 or 10 percentage critical values of the left side tail of the normal distribution. If the value surpluses further into the tail, it means that the null hypothesis will be rejected (Stock and Watson, 2015 s. 603-606). Since the null hypothesis assumes the presence of a unit root, the p-value obtained by the test should be less than the significance level to infer that the time series is stationary.

**Figure 3. The normal distribution curve**

*Source: Normal distribution curve created by the author inspired by Stock and Watson (2015 p. 97)*

If a variable is stationary from the beginning, it is said to be integrated with order zero; I(0).

If variables are non-stationary, it requires a one-order integration, I(1), to correct for a unit root. This is done by differencing the variable to become stationary. If it requires two differencing operations for a variable to become stationary, the variable is two order integration away from being stationary, I(2).

\[
y_t = \mu + y_{t-1} + b(L)e_t \quad (1)
\]
\[ y_t - y_{t-1} = \Delta Y_t = \mu + b(L) e_t \quad (1.2) \]

In regression above, the series \( y_t \) is said to be integrated of order one (1), or I(1).

### 6.2.2 Evaluation of VAR model (Granger causality test)

To measure price bubbles, a one-sided test is required to discover an explosive unit root where the critical region is seen in the right-hand tail of the normal distribution. If the variables show stationarity, it means they do not vary systematically over time and that its mean, variance and covariance are constant (Stock and Watson, 2015 s. 589).

If the null hypothesis fails to be rejected, it suggests that the time series has a unit root meaning it is not stationary and it has some time dependent structure. If the null hypothesis can be rejected, the regression has no indications of unit root, meaning it is stationary. The null hypothesis will fail to be rejected if the p-value is larger than the significance level. If the p-value is less or equal to the significant level, the null hypothesis will be rejected and the conclusion of data being non-stationary will be made.

In order to test for granger causality, Toda Yamamoto (1995) developed a method based on the estimation of augmented Vector Auto Regression model (VAR). To calculate the statistic, the deterministic components and the number of lags for each ADF regression needs to be specified (Stock and Watson, 2015 s. 593-595). Granger causality test for non-causality is being implemented to modify Wald-test for the significance of parameters.

If the p-value is greater than a certify significant level at 1% 5% or 10%, it concludes that the independent variable does not show a statistically significant relationship with the dependent variable and the null hypothesis will be accepted. If the p-value is less than the significant level, the independent variable does show a statistically significant relationship with the dependent variable and the null hypothesis can be rejected. A rejection of the null hypothesis at a level of 0.05 indicates that there is strong evidence against the null hypothesis and there is a probability of less than 5% that the null is correct.

The Granger Causality test is a statistical hypotheses test that is being used to determine whether one time series is useful in order to forecast another by studying the past values of the variables. The test is being used to investigate causality between two variables in a time series (Stock and Watson, 2015 s. 589). The definition of Granger causality is that causality is based on the idea that the past cannot be caused by the present or the future. If an event happens
before another event, causality can only appear from the first event to the second one and not vice versa (Granger, 1969). If past values of a variable can predict the present value of another variable, it is said that the first variable do Granger-cause the other one (Stock and Watson, 2015 s. 589).

The Granger causality test of Toda Yamamoto (1995) is being used in this thesis to study the relationship between the price index variable of housing in Stockholm and selected independent variables. For example, the price index variable Granger-cause GDP if the lags of the price index variable are jointly statistically significant in the GDP equation. If there is a common stochastic trend between housing prices and GDP, a causal relationship between the time series is to be expected. The null-hypothesis for the test is that X does not Granger-cause Y, meaning that the lagged values in X do not explain the variation in Y (Stock and Watson, 2015 s. 589).

Exogenous regressors needs to consist of no-regressors and an individual constant with either fixed effect or a linear trend. If the first variable is positively related to the next variable, the Granger causality test is needed in order to find out what kind of causality direction exist between them. The test determines if the causality runs from variable 1 to variable 2, or vice versa or neither.

6.2.3 The regression model
The variables that are included in the VAR model are explained in detail in chapter 4.2. The variables are; house price index, GDP, the barometer indicator, the repo rent, population, average household debt, average lending’s to households, average mortgages and consumer price index (CPI).

Where;

$\ln P$ is the coefficient for housing Price index and is the dependent variable  
$\ln Y$ is the coefficient for GDP and is independent 
$\ln BI$ is the coefficient for the barometer indicator and is independent  
$\ln RR$ is the coefficient for the repo rent and is independent  
$\ln POP$ is the coefficient for population growth and is independent  
$\ln MFI$ is the coefficient for average lending’s to households and is independent  
$\ln HD$ is the coefficient for average household debts and is independent  
$\ln RM$ is the coefficient for average real mortgages and is independent
\( \ln CPI \) is the coefficient for CPI and is independent
\( \varepsilon_{i,t} \) is the error term

**VAR model represented in equation (7) below:**

\[
\ln P_t = \mu_0 + \left( \sum_{i=1}^{k} \alpha_{1i} \ln P_{t-i} + \sum_{j=k+1}^{d_{\text{max}}} \alpha_{2i} \ln P_{t-j} \right) + \left( \sum_{i=1}^{k} \beta_{1i} \ln Y_{t-i} + \sum_{j=k+1}^{d_{\text{max}}} \beta_{2i} \ln Y_{t-j} \right)
\]

\[+ \left( \sum_{i=1}^{k} \alpha_{1i} \ln Bi_{t-i} + \sum_{j=k+1}^{d_{\text{max}}} \alpha_{2i} \ln Bi_{t-j} \right) + \left( \sum_{i=1}^{k} \delta_{1i} \ln rr_{t-i} + \sum_{j=k+1}^{d_{\text{max}}} \delta_{2i} \ln rr_{t-j} \right)
\]

\[+ \left( \sum_{i=1}^{k} \gamma_{1i} \ln pop_{t-i} + \sum_{j=k+1}^{d_{\text{max}}} \gamma_{2i} \ln pop_{t-j} \right) + \left( \sum_{i=1}^{k} \theta_{1i} \ln mf_{t-i} + \sum_{j=k+1}^{d_{\text{max}}} \theta_{2i} \ln mf_{t-j} \right)
\]

\[+ \left( \sum_{i=1}^{k} \varphi_{1i} \ln rm_{t-i} + \sum_{j=k+1}^{d_{\text{max}}} \varphi_{2i} \ln rm_{t-j} \right) + \left( \sum_{i=1}^{k} \sigma_{1i} \ln h_d_{t-i} + \sum_{j=k+1}^{d_{\text{max}}} \sigma_{2i} \ln h_d_{t-j} \right)
\]

\[+ \left( \sum_{i=1}^{k} \sigma_{1i} \ln cp_{t-i} + \sum_{j=k+1}^{d_{\text{max}}} \sigma_{2i} \ln cp_{t-j} \right) + \varepsilon_{i,t}
\]

(7)

The VAR model \((k + d_{\text{max}})\) represented in equation (7) above, where \(k\) is the optimal time lag on the first VAR model and \(d_{\text{max}}\) is the maximum integrated order on the variables of the system. In the Toda Yamamoto Granger causality approach, each series has an integration order and if the order is different, we get the maximum \((d_{\text{max}})\). The highest integration order is found by processing a unit root test where all variables run against the Dickey-Fuller command with appropriate lags. When finding the highest integration order, the VAR model is created from the levels of series by using suitable lags for each series.

The null- and the alternative hypothesis is shown below.

\[H0: \sum_{i=1}^{k} \alpha_{1i} > 0 \text{ and } \beta_{1,1} = \beta_{1,2} = \cdots = \beta_{1,k} = 0 \]

\[H1: \sum_{i=1}^{k} \alpha_{1i} < 0 \text{ and } \beta_{1,1} = \beta_{1,2} = \cdots = \beta_{1,k} \neq 0 \]

\(H0\) represents the null hypothesis, stating that the independent variable \((\beta)\) does not Granger cause the dependent variable \((\alpha)\). It means that the dependent variable cannot be explained by
fundamental factors and there is a risk that it is self-running and only gets effected by its own lags (Stock and Watson, 2015 s. 600).

While H1 represents the alternative hypothesis where the independent variable (β) does Granger-cause the dependent one (α), meaning that the historical values of the independent variables can explain the development in the dependent one.

When running a regression, one variable with historical values of itself will be tested against the past value of a potential causal variable. This is made in order to test the significance of coefficient to see if it estimates an association with the potential causal variable and the hypothesis will be rejected at a certain level if the probability value is less than that.

To discover causality, the variables usually get swished in a second equation. Although, this thesis attempts to find out if the independent variables affect the price and not vice versa, making a second equation not important in this specific case.

6.3 Limitations for the model

Limitations for the model is that this thesis holds its focus on GDP level and actual income and do not include the net worth of individuals. More and more people are investing in the stock market, yet the stock market development during the years is not included in the regression. Since the stock market has had a positive trend since the financial crisis of 2008, it could imply that shareholders have become wealthier. Even though the saving quote is included in the regression (through debt-to-income variable), the dividend in the stock market is not taken in advance. This could be a possible explanation of individuals affording more expensive housing without a higher income.

Another limitation is that the thesis does not takes seasonality in advance. Since data is quarterly based, there could be seasonality effects that could have inputs on the results. To deal with seasonality in regression models, a usual tool for control is to include dummy variables that represents spring, summer, autumn and winter where one of them could be set as a reference point that the other ones would be compared to. By doing so, the model will account for seasonality when the data is not adjusted to seasons.

A third limitation is because of the long time period, political events or changes in the government that could have effects on the barometer indicator is not included.
7. Results
This chapter introduces the results of the thesis. It starts by a presentation of the actual price development in purpose to draw a conclusion whether implementation of new requirements have an effect on pricing. Secondly, the result of the VAR-model of Granger Causality and the Wald-test will be given in order to find out if there are indications of an existing price bubble.

7.1 The effect of stricter requirements on housing prices
Information from the HOX Price index show that the implementation of stricter regulations has no direct effect on housing prices. The graph below highlights the quarters when the Swedish financial supervisory set new requirements on the housing market. The price index of housing in Stockholm is shown on the y-axis represented in number of thousands and quarterly based data between 2007-2020 is represented on the x-axis.

The price development has a strong positive trend regardless the new requirements being set.

- **First quarter of 2010**: New mortgage ceiling
- **Second quarter of 2016**: Stricter amortization requirements
- **First quarter of 2018**: Maximum loan is 4,5 times total gross income

Figure 4. The price index development in Stockholm

Source: Nasdaq OMX Valueguard-KTH Housing Index (HOX®) 2021
7.2 VAR-model of Granger Causality
The highest integration order is designated by the Akaike information criterion\(^5\) (AIC) that chooses the optimal lags \((k)\) for the regression (Stock and Watson, 2015 s. 595). The optimal lags for this regression are 4, meaning \((k = 4)\) in our VAR model of Granger causality.

The variables that are included in all results from the statistical program STATA is: The price index variable, GDP, the barometer indicator, population, the repo rent, average debt-to-income ratio, average lending to households, average mortgages and consumer price index.

Table 2. Selection-order criteria using AIC to choose optimal lags
Sample: 2008q1 – 2020q4, Number of obs. = 52

<table>
<thead>
<tr>
<th>Lag</th>
<th>LL</th>
<th>LR</th>
<th>df</th>
<th>P</th>
<th>FPE</th>
<th>AIC</th>
<th>HQIC</th>
<th>SBIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1084.99</td>
<td>1299.3</td>
<td>81</td>
<td>0.000</td>
<td>2.0e-28</td>
<td>-38.2689</td>
<td>-39.9742</td>
<td>-34.8917</td>
</tr>
<tr>
<td>2</td>
<td>1231.18</td>
<td>292.37</td>
<td>81</td>
<td>0.000</td>
<td>2.2e-29</td>
<td>-40.776</td>
<td>-38.316</td>
<td>-34.3594</td>
</tr>
<tr>
<td>3</td>
<td>1400.62</td>
<td>338.9</td>
<td>81</td>
<td>0.000</td>
<td>1.7e-30</td>
<td>-44.1779</td>
<td>-40.5527</td>
<td>-34.7219</td>
</tr>
<tr>
<td>4</td>
<td>1603.51</td>
<td>405.76*</td>
<td>81</td>
<td>0.000</td>
<td>1.2e-31*</td>
<td>-48.8656*</td>
<td>-44.0752*</td>
<td>-36.3702*</td>
</tr>
</tbody>
</table>

\(\text{Source: Author's calculations through STATA}\)

The Augmented Dickey-Fuller unit root test tells from the t-statistics and p-value that variables are non-stationary in first run, meaning the t-statistics do not exceed the critical values and the p-value is larger than the significant level.

To become stationary, data is being differenced, meaning it requires a one-order integration to correct for a unit root, \(1(1)\).

This implies that \(d_{\text{max}} = 1\) in our VAR-model of Granger causality in equation (8) below.

\[
\ln P_t = \mu_0 + \left( \sum_{i=1}^{4} \alpha_{1i}\ln P_{t-i} + \sum_{j=4+1}^{1} \alpha_{2j}\ln P_{t-j} \right) + \left( \sum_{i=1}^{4} \beta_{1i}\ln Y_{t-i} + \sum_{j=4+1}^{1} \beta_{2i}\ln Y_{t-j} \right) \\
+ \left( \sum_{i=1}^{4} \alpha_{1i}\ln B_{i-t-i} + \sum_{j=4+1}^{1} \alpha_{2j}\ln B_{i-t-j} \right) + \left( \sum_{i=1}^{4} \delta_{1i}\ln r_{r_t-i} + \sum_{j=4+1}^{1} \delta_{2i}\ln r_{r_t-j} \right) \\
+ \left( \sum_{i=1}^{4} \gamma_{1i}\ln p_{0p-t-i} + \sum_{j=4+1}^{1} \gamma_{2i}\ln p_{0p-t-j} \right) + \left( \sum_{i=1}^{4} \theta_{1i}\ln m_{f-t-i} + \sum_{j=4+1}^{1} \theta_{2i}\ln m_{f-t-j} \right)
\]

\(^5\) The Akaike information criterion is an estimate of prediction errors and thus the relative quality of statistical models for a given set of data.
\[
+ \left( \sum_{i=1}^{4} \phi_{1i} \ln m_{t-i} + \sum_{j=4+1}^{1} \phi_{2j} \ln m_{t-j} \right) + \left( \sum_{i=1}^{4} \sigma_{1i} \ln h d_{t-i} + \sum_{j=4+1}^{1} \sigma_{2j} \ln h d_{t-j} \right)
+ \left( \sum_{i=1}^{4} \sigma_{1i} \ln c p_{i,t-i} + \sum_{j=4+1}^{1} \sigma_{2j} \ln c p_{i,t-j} \right) + \epsilon_{it}
\] (8)

The VAR model contains significant values, which is enough evidence to conclude that the price index variable can be explained by other variables. The null hypothesis will therefore be rejected in the VAR test which supports the presence of Granger causality.

**Table 3. VAR model with optimal lags (4 + 1)**

<table>
<thead>
<tr>
<th>Price index</th>
<th>Coef.</th>
<th>Std. Err.</th>
<th>t</th>
<th>P&gt;t</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1.</td>
<td>0.2270865</td>
<td>0.2763788</td>
<td>0.82</td>
<td>0.449</td>
<td>-0.4833678 - 0.9375407</td>
</tr>
<tr>
<td>L2.</td>
<td>-0.6586048</td>
<td>0.2322173</td>
<td>-2.84</td>
<td>0.036</td>
<td>-1.255538 - 0.0616713</td>
</tr>
<tr>
<td>L3.</td>
<td>0.2933087</td>
<td>0.189367</td>
<td>1.55</td>
<td>0.181</td>
<td>-0.1923687 - 0.778961</td>
</tr>
<tr>
<td>L4.</td>
<td>0.4586529</td>
<td>0.2103315</td>
<td>2.18</td>
<td>0.081</td>
<td>-0.0820214 - 0.9993273</td>
</tr>
<tr>
<td>L5.</td>
<td>-0.1114583</td>
<td>0.2388344</td>
<td>-0.47</td>
<td>0.660</td>
<td>-0.7254016 - 0.502485</td>
</tr>
</tbody>
</table>

*Source: Author's calculations through STATA*

If \( p < 0.1 \), the null hypothesis will be rejected.

**7.3 Wald test**

The result of the Wald test is represented by each one of the independent variables in table below and is based on their result in STATA. Outcomes from STATA is found in the appendix (chapter 11 in this thesis). The Wald-test tells us if the independent variable Granger-cause the dependent variable (the price index). If the independent variable show a significant result (a \( p \)-value less than 0.01) the conclusion is that it does Granger-cause the price index variable.

**Table 4. Result of Wald-test**

<table>
<thead>
<tr>
<th>Fundamental</th>
<th>P-value</th>
<th>Result</th>
<th>Outfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>0.0161</td>
<td>Significant</td>
<td>Rejecting the null at 5%</td>
</tr>
<tr>
<td>Barometer indicator</td>
<td>0.0205</td>
<td>Significant</td>
<td>Rejecting the null at 5%</td>
</tr>
<tr>
<td>Population</td>
<td>0.4199</td>
<td>Non-significant</td>
<td>Accepting the null</td>
</tr>
<tr>
<td>Repo rent</td>
<td>0.1940</td>
<td>Non-significant</td>
<td>Accepting the null</td>
</tr>
<tr>
<td>Debt-to-income</td>
<td>0.2353</td>
<td>Non-significant</td>
<td>Accepting the null</td>
</tr>
<tr>
<td>Lending to households</td>
<td>0.0703</td>
<td>Significant</td>
<td>Rejecting the null at 10%</td>
</tr>
<tr>
<td>Mortgages</td>
<td>0.0443</td>
<td>Significant</td>
<td>Rejecting the null at 5%</td>
</tr>
<tr>
<td>CPI</td>
<td>0.0228</td>
<td>Significant</td>
<td>Rejecting the null at 5%</td>
</tr>
</tbody>
</table>

*Source: Author's calculations through STATA, see appendix*
Wald test of GDP

The variable has a p-value of 0.0161 which is smaller than the critical value of 0.05, meaning that the GDP variable is statistically significant and the null hypothesis can be rejected. The conclusion is that the historical GDP could predict the price index variable.

Wald test of the barometer indicator

The variable has a p-value of 0.0205 which is smaller than the critical value of 0.05, meaning that the barometer indicator is statistically significant with the price index variable. The null hypothesis can be rejected and the conclusion is that the historical barometer indicator can predict the price index variable.

Wald test of population

The variable has a p-value of 0.4199 which is greater than the critical value of 0.05, meaning that population is not statistically significant with the price index variable. The null hypothesis will therefore not be rejected and the conclusion is that the historical population does not affect the price index variable.

Wald test of the repo rent

The variable has a p-value of 0.1940 which is greater than the critical value of 0.05, meaning that the repo rent is not statistically significant with the price index variable. The null hypothesis will be accepted and the conclusion is that the past repo rent does not affect the price index variable.

Wald test of the debt-to-income variable

The variable has a p-value of 0.2353 which is greater than the critical value of 0.05, meaning that the average debt-to-income variable is not statistically significant with the price index variable. The null hypothesis fails to be rejected and the conclusion is that the past values of the average debt-to-income does not affect the price index variable.

Wald test of the lending to household's variable

The variable has a p-value of 0.0703 which is greater than the critical value of 0.05, meaning that the average lending to household’s variable is not statistically significant at 10% with the price index variable. The null hypothesis will therefore not be rejected and the conclusion is that the past values of lending to household’s does not affect the price index variable.
**Wald test of mortgages**

The variable has a p-value of 0.0443 which is smaller than the critical value of 0.05, meaning that the variable mortgages are statistically significant with the price index variable. The null hypothesis can be rejected and the conclusion is that the historical average mortgages do predict the price index variable.

**Wald test of CPI**

The variable has a p-value of 0.0228 which is smaller than the critical value of 0.05, meaning that CPI is statistically significant with the price index variable. The null hypothesis can be rejected and the conclusion is that historical CPI do affect the price index variable.

### 7.4 Summary

By choosing eight relevant variables that were tested against the dependent variable (the price index), it was concluded that there is no evidence of an existing housing bubble. Lags are created to find out if the present value of housing prices is being affected by historical values of some economic key variables. This paper does find the evidence that the historical values of GDP, the barometer indicator, average lending to households, average mortgages and CPI can predict the housing price, which is enough evidence to reject the null hypothesis of a price bubble.

### 8. Analysis

*This chapter analysis and discusses the result of the thesis by connecting previous presented theory to the outcome.*

**The market theory**

The Wald-test shows significant results of the following variables: GDP, the barometer indicator, lending to households, mortgages and CPI, meaning that the historical values of those variables can explain the current development in the price index variable. The market theory explains how the price level of the housing market can be changed when a significant event happens that affects the demand (or supply) curve.

The result shows that GDP level follows a positive trend, which has an effect on the demand curve, making it shift upwards and prices will rise.
The GDP level has a similar trend as the price index variable with a positive development. The red circled areas represent tops where exogenous events occurred that deviates from the standard. The first top that occurs between 2007-2009 is the financial crisis and the second top arrives due to the corona crisis in 2020 when the Swedish stock market had the biggest fall in 33 years (Ekonomistas, 2020). Overall, the conclusion can be made that GDP follow the same trend as the price index and the Wald test show significant level meaning that GDP can explain the development in the price index variable. This gives support to the market theory, where a rise in GDP shifts the demand curve upwards making price to rise.

The market theory confirms that an increase in CPI do have a positive effect on the price variable. Similar to the development in GDP, the CPI got affected negatively due to the financial crisis and corona crisis (red circled areas in the graph). Overall, a positive trend in CPI is observed which has a positive effect on pricing. The development in CPI gives support to the price index variable according to the market theory.
The Greater fool theory

The housing prices in Stockholm have experienced a massive growth the latest decades, combined with low interest rates and income growth. The population in Stockholm has increased due to urbanization and migration. These are all factors that drives the demand of housings and hence, affects the prices.

Figure 7. The price index development in Stockholm years 2007 – 2020, quarterly based

Source: Nasdaq OMX Valueguard-KTH Housing Index (HOX®) 2021

Implementing the mortgage ceiling in the first quarter of 2010 gave no effect on the price development since there is a steep increase in pricing from that quarter that continues to 2017. There is an observation of a slightly cool off in the market after the implementation of the stricter amortization requirements in the second quarter of 2016. Although, other factors might have caused that dip. After the last requirement set in the first quarter of 2018, the positive trend in price developing continues.

Figure 8. The barometer indicator years 2007 – 2020, quarterly based

Source: Ekonomifakta (2021,1)

The graph above shows the barometer indicator on the y-axis and time on the x-axis. A short time after the mortgage ceiling was implemented in 2010, the expectations of the market
decreased by a large amount. After the fall, the expectations recovered and rose until the amortization requirement was set in 2016 where there is an observation of a fall in expectations of a milder degree.

When the last requirement was set in 2018, there is a falling trend in the barometer indicator meaning that expectations of the market were low at that point.

The barometer indicator shows a significant result in the Wald-test that rejects the hypothesis of a potential price bubble. The indicator contains expectations of the economic situation and people tend to invest more if the expectation of the market is positive. Although, in periods where the barometer shows little expectations in the market, the price index variable continues to increase anyway. This concludes that even if the expectation in the economic market is low, people continue to invest in properties and buy at high prices. This conclusion can be related to the Greater fool theory (represented in chapter 3.2) that explains that people continue to buy at high prices in belief that there will always be a bigger fool who is willing to pay an even higher price in the future.

**Price bubble theory**

The price bubble theory explains that macroeconomic factors such as low interest rates, high employment rate and high incomes are all factors that drives the demand in the market.

In chapter 3.3 (Price bubble theory) there are three criterions presented as the most important ones when trying to spot housing bubbles and the first criteria is when the market has low interest rates. Sweden has experienced low levels in interest rates for a long time, in some periods even negative levels. The Wald test of the repo rent is non-significant which means it could fulfil the first criteria of the price bubble theory.

**Figure 9. The repo rent in Sweden years 2007 – 2020, quarterly based**

![The repo rent (SCB, 2021.5)](image)
Although, low interest rates are not enough evidence to point out the market as overvalued. Formation of bubbles are a complex phenomenon that could depend on the interaction on several factors and is therefore difficult to point out. Despite that the variables: Population, the repo rent and debt-to-income are non-significant in the Wald test, it still does not conclude there is evidence of an existing bubble since the price index variable can be explained by the rest of the chosen independent variables.

8.1 Discussion
As Birch Sørensen (2013) confirms, it is difficult to discover price bubbles since there are no uniform model when studying house prices. The Toda Yamamoto approach says if one of the independent variables can predict the development in the dependent variable, a price bubble is supposed to be rejected. Although, the result given is that debt-to-income shows a non-significant result which rises suspicions among price bubbles. Having too much debt rise the risk of individual’s running default in case of a price fall. Or, too much debt might lead to individual’s facing trouble to pay for their mortgages which also has an economic defect.

When the mortgage ceiling was implemented, lending to households faced a steep decrease and after a small recovery and new requirements were set, it decreased again\(^6\). Mortgages increased in 2010, which could be explained as either recovery after the financial crisis or that people hurried to buy before the ceiling was completely set. In the last quarter of 2010, the mortgages followed the same decreasing trend as lending. This finding does support the findings of Duca et.al., (2011) who said that implementing a mortgage ceiling could be an effective solution to cool off a heated market.

The average debt-value of the households has not followed the same pattern\(^7\), rather, it has had a steep increase. This is particularly interesting, since the idea of implementing stricter regulations is to lower the debt-value of the households.

One of the aims for this thesis was to understand if the implementation of stricter requirements influences the indebtedness of households in Stockholm, or if there are tendencies that it eventually will. The Wald-test shows a non-significant result meaning debt-to-income does not have an impact on housing prices. Judging from the graphs below, this thesis contributes with the findings that implementing stricter requirements does not influence average debt-to-income, which was the purpose of the implementation.

\(^6\) See graph 11, p. 43
\(^7\) See graph 12, p. 43
Figure 10. Average lending to households years 2007 – 2020, quarterly based

Source: SCB, 2021.2

Figure 11. Average mortgages years 2007 – 2020, quarterly based

Source: SCB (2021.4)

Figure 12. Average debt-to-income years 2007 – 2020, quarterly based

Source: SCB (2021.3)
9. Future research
This last chapter contains suggestions to future research if one would aim to improve this thesis in order to reach a more significant result. The chapter ends with self-critique, that also is necessary if the research would be continued.

9.1 Suggestions
The main focus of this thesis was to investigate the GDP variable (set as a proxy for average income) to understand the rapid price development in Stockholm. The GDP variable contains information about the average income level in Sweden but it does not include private investments in the stock market. The stock market has faced a positive development since the fall caused by the financial crisis in 2008-2009. Individuals who have invested in the stock market may have increased their wealth significantly through dividends.

Figure 12. The development in the Swedish OMX30 index from 1996 – 2020

Source: Tradingview (2021)

It would have been desirable to leverage data on average quarterly incomes in Stockholm specifically, but that kind of information is only available on an annual basis. Since this thesis is interested in investigating events that occurs on specific quarters during the observed period, it is not optimal to use the annual average income and split equally across all quarters. Additionally, wage setting is also individual and differs in how it’s setup between companies. The GDP level is therefore considered the best option for this thesis, as it includes salary and profit and the capital of Sweden should not deviate from the development in GDP (LO, 2018). Although, for future research it would be interesting if quarterly data of average income of Stockholm somehow could be found.
Another variable that could be included is the unemployment rate, especially in smaller cities outside Stockholm. The cost of living is usually more expensive in the capital compared to other cities in a country, and the capital also tends to attract more people since it often can provide more job opportunities than in smaller cities. The variable population is included in our regression already, but it could be developed by investigating migration from smaller cities more closely and include the unemployment rate in smaller cities compared to Stockholm. When a city has a surplus of supply in work, the willingness of moving there will rise, which would increase the demand of housing.

9.2 Critique

The total observation period of 14 periods contains 56 quarters, which could be seen as too short of a time period. If 10 more years of data could have been included, the result might have turned out differently since the years before the financial crisis would have been interesting to observe. The result would probably be more robust if a longer data set would have been included.

Also, it is always more difficult to investigate one specific city, since a lot of data is based on the entire country. One solution could be to include other cities and then compare them to both Stockholm and Sweden to see if the pricing development in Stockholm stands out in comparison.

If more data would have been added to the research, the number of lags could be bigger, which could have an effect of the precision of the model. This is especially important since long-run coefficients sometimes diverges from the theoretical expectations, which might not be noticed when lags are small. Adding more data would help the study to ensure that more lags could be used.

One strength with the model is that the data reflects economic theory and the main factors that have an effect of demand in the housing market. Another strength is that the observations include both the financial crisis and the first two years of the corona crisis, meaning there are two economic shocks included in the model. This is an advantage in order to discover how the independent variables behaves against the pricing index in those times.
9.3 Conclusion

The aim of this study was to investigate the housing market of Stockholm and to figure out if there are indications of an existing price bubble. It was concluded that the price development of housing in Stockholm is partially predictable, hence there is little evidence to show that housing prices are being self-running.

The historical values of GDP, the barometer indicator, lending to households, mortgages and CPI do get Granger-caused by the price index variable, which means that the development in housing prices can be explained by those variables.

The result given is a rejection of the null hypothesis, meaning there is not enough evidence pointing towards a housing bubble in Stockholm. However; housing prices will not be able to continue to increase forever and the market could still face a decline moving forward. Additionally, current discussions about the central bank wanting to rise the interest rate in the short term is a factor that, according to the market theory, may have a negative effect on housing prices when they go up. Therefore, it is crucial to continue to investigate the economic situation of Sweden to make a conclusion about the future developments in housing prices.
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11. Appendix

The following tables show the result of the Wald-test performed in STATA. The variables included are: Price index variable (logHOXFLATSTO), GDP (logGDP), The barometer indicator (BAROINDICATOR), population (logPOP), the repo rent (REPO), average debt-to-income ratio (logDEBTVALUE), average lending to households (logLENDING), average mortgages (logMORTGAGE) and consumer price index (logCPI).

Wald test to find out if the GDP variable Granger-Cause the Price index variable
Optimal lag = 4

(1) \[ \text{logHOXFLATSTO}_L \cdot \text{logGDP} - \text{logHOXFLATSTO}_L2 \cdot \text{logGDP} = 0 \]
(2) \[ \text{logHOXFLATSTO}_L \cdot \text{logGDP} - \text{logHOXFLATSTO}_L3 \cdot \text{logGDP} = 0 \]
(3) \[ \text{logHOXFLATSTO}_L \cdot \text{logGDP} - \text{logHOXFLATSTO}_L4 \cdot \text{logGDP} = 0 \]
(4) \[ \text{logHOXFLATSTO}_L \cdot \text{logGDP} = 0 \]

\[ F(4,5) = 9.12 \]
\[ \text{Prob > F} = 0.0161 \]

Wald test to find out if the Barometer indicator Granger-Cause the Price index variable
Optimal lag = 4

(1) \[ \text{logHOXFLATSTO}_L \cdot \text{BAROINDICATOR} - \text{logHOXFLATSTO}_L2 \cdot \text{BAROINDICATOR} = 0 \]
(2) \[ \text{logHOXFLATSTO}_L \cdot \text{BAROINDICATOR} - \text{logHOXFLATSTO}_L3 \cdot \text{BAROINDICATOR} = 0 \]
(3) \[ \text{logHOXFLATSTO}_L \cdot \text{BAROINDICATOR} - \text{logHOXFLATSTO}_L4 \cdot \text{BAROINDICATOR} = 0 \]
(4) \[ \text{logHOXFLATSTO}_L \cdot \text{BAROINDICATOR} = 0 \]

\[ F(4,5) = 8.14 \]
\[ \text{Prob > F} = 0.0205 \]

Wald test to find out if population Granger-Cause the Price index variable
Optimal lag = 4

(1) \[ \text{logHOXFLATSTO}_L \cdot \text{logPOP} - \text{logHOXFLATSTO}_L2 \cdot \text{logPOP} = 0 \]
(2) \[ \text{logHOXFLATSTO}_L \cdot \text{logPOP} - \text{logHOXFLATSTO}_L3 \cdot \text{logPOP} = 0 \]
(3) \[ \text{logHOXFLATSTO}_L \cdot \text{logPOP} - \text{logHOXFLATSTO}_L4 \cdot \text{logPOP} = 0 \]
(4) \[ \text{logHOXFLATSTO}_L \cdot \text{logPOP} = 0 \]

\[ F(4,5) = 1.18 \]
\[ \text{Prob > F} = 0.4199 \]

Wald test to find out if the repo rent Granger-Cause the Price index variable
Optimal lag = 4

(1) \[ \text{logHOXFLATSTO}_L \cdot \text{REPO} - \text{logHOXFLATSTO}_L2 \cdot \text{REPO} = 0 \]
(2) \[ \text{logHOXFLATSTO}_L \cdot \text{REPO} - \text{logHOXFLATSTO}_L3 \cdot \text{REPO} = 0 \]
(3) \[ \text{logHOXFLATSTO}_L \cdot \text{REPO} - \text{logHOXFLATSTO}_L4 \cdot \text{REPO} = 0 \]
(4) \[ \text{logHOXFLATSTO}_L \cdot \text{REPO} = 0 \]
Wald test to find out if debt-to-income Granger-Cause the Price index variable
Optimal lag = 4

(1) $\text{logDEBTVALUE}_t - \text{logDEBTVALUE}_{t-2} = 0$
(2) $\text{logDEBTVALUE}_t - \text{logDEBTVALUE}_{t-3} = 0$
(3) $\text{logDEBTVALUE}_t - \text{logDEBTVALUE}_{t-4} = 0$
(4) $\text{logDEBTVALUE}_t = 0$

$F(4, 5) = 2.29$
$Prob > F = 0.1940$

Wald test to find out if lending to households Granger-Cause the Price index variable
Optimal lag = 4

(1) $\text{logLENDING}_t - \text{logLENDING}_{t-2} = 0$
(2) $\text{logLENDING}_t - \text{logLENDING}_{t-3} = 0$
(3) $\text{logLENDING}_t - \text{logLENDING}_{t-4} = 0$
(4) $\text{logLENDING}_t = 0$

$F(4, 5) = 4.31$
$Prob > F = 0.0703$

Wald test to find out if the mortgages variable Granger-Cause the Price index variable
Optimal lag = 4

(1) $\text{logMORTGAGE}_t - \text{logMORTGAGE}_{t-2} = 0$
(2) $\text{logMORTGAGE}_t - \text{logMORTGAGE}_{t-3} = 0$
(3) $\text{logMORTGAGE}_t - \text{logMORTGAGE}_{t-4} = 0$
(4) $\text{logMORTGAGE}_t = 0$

$F(4, 5) = 5.54$
$Prob > F = 0.0443$

Wald test to find out if the CPI variable Granger-Cause the Price index variable
Optimal lag = 4

(1) $\text{logCPI}_t - \text{logCPI}_{t-2} = 0$
(2) $\text{logCPI}_t - \text{logCPI}_{t-3} = 0$
(3) $\text{logCPI}_t - \text{logCPI}_{t-4} = 0$
(4) $\text{logCPI}_t = 0$

$F(4, 5) = 7.73$
$Prob > F = 0.0228$