Camilla Løfsgaard Lie
Supervisor: Edward Vali

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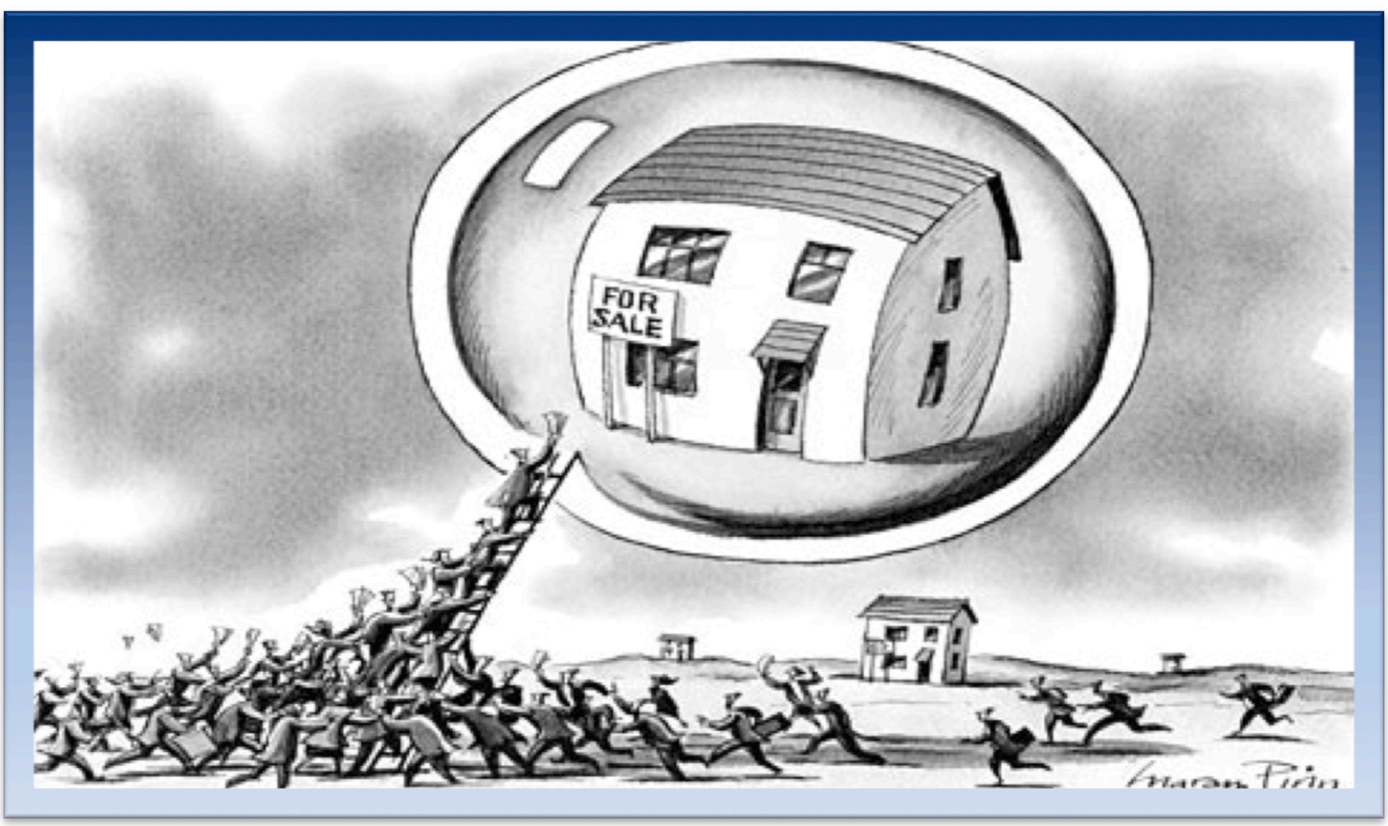
An empirical analysis of the housing market in Oslo

DO WE SEE SIGNS OF A POTENTIAL HOUSING BUBBLE?



Preface

The investigation for this thesis started up as a partnership with Camilla Maltina Gravdal. Due to unforeseen personal circumstances, we had to break up the partnership. The partnership ended before we started the collaborative writing process, and the product of this thesis is therefore entirely produced by the undersigned. Discussions about the topic can however have influenced my ideas for the structure of the thesis.

Camilla Løfsgaard Lie, Copenhagen 15 September 2017

Abstract

In this dissertation I will investigate the price development in the housing market in Oslo in recent time. I want to analyze what the most fundamental factors driving the house price development are, and how strongly the price development react to changes in these factors. The main objective for writing this thesis is to analyze what drives the price development in the housing market in Oslo in order to answer the following question: "Are there indications pointing towards a bubble in the housing market in Oslo?".

In my analysis of the house price development in Oslo I find that house prices grow faster than the inflation, rents, and construction costs. I interpret this as the housing prices are inflated compared to the overall economy. The question is whether this excessive price growth can be explained by development in underlying fundamental factors, or whether this price increase is an indication of a speculative bubble building up in the market. To investigate this question I conduct an econometric analysis of the housing market in Oslo between the first quarter of 2000 and the fourth quarter of 2016. The explanatory variables chosen for the analysis are: unemployment, interest rate, income, household expectations and housing construction. My results show that much of the development in housing prices can be explained by development in underlying fundamental factors. Further, I found that interest rate and unemployment are the two most important fundamental factors explaining the house price development in Oslo. The econometric modeling an testing has been conducted in Eviews and the other data processing has been conducted in Excel.

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1.0. Introduction

1.1. Introduction and problem statement

The Norwegian housing market has experienced an excessive house price growth the last 24 year. The market is currently booming, and according to Statistical Bureau of Norway (SSB), real house prices in Norway have on average increased by around 7 percent yearly since 1993. Only with an exception of a small decline as a result of the financial crisis in 2008, the real housing prices have increased continuously in Norway. Looking at other developed economies in Europe and the US, we see a very different picture. In many western economies, housing prices are still lower than before the crisis (Krakstad & Oust, 2015). This development has raised the interest of many economists, not only in Norway, but also internationally. The well-known American economist, Robert J. Shiller, raised his concern about a potential housing bubble in the Norwegian housing market all the way back in 2012, but the price growth has just continued. Even the huge set back in the oil market in 2014 did not manage to slow down the excessive house price growth.

The Norwegian housing market is further characterized by large regional differences in house price development, where the largest cities have experienced the highest price growth in recent years. One exception here is Stavanger, which due to the oil plunge in 2014 has experienced declining housing prices the last three years (SSB, 2016b). The highest price growth is seen in Oslo. The house price per square meter has grown by approximately 853 percent the last 24 years in Oslo, and in 2016 alone there was a price increase of 25 percent (NCB, 2016). The population growth in Oslo has been high, much due to migration and urbanization, and the population has grown from 473 454 to 658 390 people the last 24 years (SSB, 2017a). Further, the Norwegian economy has been characterized by low unemployment, income growth and low interest rates. These factors have driven the housing demand in Oslo. Due to several reasons, with regulation on land use and demanding construction standards being two of the most important, housing construction has not met this increase in housing demand, and a gap between supply and demand has emerged (IMF, 2015).

The future economic outlooks are uncertain both in Norway and in the world as a whole. The world economy has the last couple of years been influenced by a recession due to falling oil prices and instability due to political changes, such as BREXIT and the seating of a new American president. This has especially affected the Norwegian economy through Norway's terms of trade with the rest of the world. As a mean to counteract a potential recession in the Norwegian economy, the National Central Bank (NCB) has sat the key ratio as low as

0.5 percent. This is the lowest in the history of the Norwegian economy. With increasing housing prices in Oslo this do however raise a dilemma for the NCB, as low interest rates work as an amplifier for the price growth in the housing market. Other measures attempting to decrease the housing demand in the market have therefore been implemented by the government, the most recently being stricter lending policies functioning from the 1th of January 2017.

A potential housing bubble can have huge implications for the economic stability in Norway. The financial crisis in 2008 showed the possible consequences of a housing bubble for the rest of the economy, further fueling the interest of studying housing bubbles both among economists and policy makers (Mayer, 2011). The housing investment is the biggest investment a household makes during a lifetime. A bust in the housing market will therefore have a huge impact on household wealth, which will further affect public consumption (Black, Fraser & Hoseli, 2006). The fact that dwellings most often are highly debt-financed and collateralized by the property itself, further increases the instability in case of a decline in housing prices through a potential spillover-effect between the housing market and the credit market (Anundsen, 2013). A decline in housing prices and consumption will further affect the residential investment negatively. This has a negative effect both on GDP and the employment level.

Other important characteristics with the housing market that makes it interesting to investigate for bubbles, are limited arbitrage due to high transaction costs, heterogeneity, and illiquidity associated with housing. The process of a market correction in case of a price deviation from equilibrium price is therefore more difficult, and the process may be prolonged for an uncertain period of time (Black, Fraser & Hoseli, 2006). In addition, housing works as both a consumption good and as a pure investment instrument. This makes the market more complicated as speculation may develop in the market, resulting in self-fulfilling price increases (Larsen, 2005). Understanding how and why house prices move, is therefore important both for policy makers and for people who want to make sound financial decisions (Nakajima, 2011). An important difference between the housing market and other financial markets, such as the stock market, is that the majority of the buyers in the stock market are professional investors. In the housing market on the other hand, the majority of the buyers buy dwellings for consumption purposes (Jacobsen & Naug, 2004). It is therefore reasonable to assume that the buyers in the housing market have a weaker understanding of the concept of risk. Revealing indications of a housing bubble before it burst is therefore important in order to restrain the economic consequences of a bubble.

Expectations about how the Norwegian housing market will develop the next couple of years is a hot topic both in the media and academically. Economists and experts are split in their belief about the future development in the housing market in Oslo. While some are concerned that the excessive price growth is a bubble waiting to burst, others explain the high price growth based on underlying fundamental factors. It is therefore interesting to investigate if the housing market in Oslo has indications of a price bubble today, or if the excessive price growth in the market can be explained by changes in underlying fundamental factors[1].

Problem statement

Based on this I have decided on the following problem statement for my thesis:

"Are there indications pointing towards a bubble in the housing market in Oslo?"

To answer this question, I will investigate the following sub-questions:

1. What are the key fundamental factors driving supply and demand in the housing market?
2. How has the housing prices in Oslo reached todays level?
3. To what extent can the development in key fundamental factors explain the excessive house price growth in Oslo?

Based on economic theory and earlier studies in this area I will develop my own house price model, which will be used to investigate this problem statement through econometric analysis. Due to the complexity of the housing market, where both economic factors and expectations are important variables affecting the price development, it is very difficult to identify a housing bubble before it burst. I will therefore not take on such a task in this thesis. I will on the other hand investigate if we can see *indications* of a potential housing bubble in the housing market in Oslo.

[1] Underlying fundamental factors are here defined as economic factors affecting the supply and demand dynamics in the housing market, one example being disposable income.

1.2. Delimitations

I will here provide the reader with the delimitations I have chosen for this dissertation in order to give a clear picture of the scope of the dissertation.

First of all, I have chosen to focus solely on the housing market in Oslo instead of the entire Norwegian housing market. Investigating the entire Norwegian housing market would be interesting, but as the Norwegian housing market consist of big regional differences, I find that the entire market requires a bigger scope in order to fully get a comprehensive picture. The highest price growth is seen in Oslo, and I therefore find this market the most interesting to analyze for a potential housing bubble in Norway. Further, most of the previous Norwegian housing studies have focused on the Norwegian market as a whole, and I therefore find it interesting to focus solely on Oslo in order to add to existing literature.

The housing market in Oslo consist of different types of housing, such as: detached houses, row houses and multi-dwelling houses. Further, the market is characterized with a high degree of heterogeneity, both due to differences in housing quality and location. This makes it a difficult market to analyze, and I have therefore limited myself not to distinguish between different housing types in my analysis, but to analyze the market as a whole. The terms *housing*, *dwelling*, and *house* will therefore be used interchangeably, and will all refer to the market as a whole.

Housing demand consist of two different types of buyers; people who are buying dwellings as a consumption good and people who are buying dwellings as a pure investment instrument. It is reasonable to assume that that the majority of buyers in the real estate market buy dwellings as a consumption good (Jacobsen & Naug, 2004). I will therefore focus on owner-occupied demand in my analysis, and I will further assume that this demand is proportional to the total housing demand in the market.

The housing market is closely related to the rental market as housing services may be consumed either by owning or by renting a dwelling (Jacobsen & Naug, 2004). The rental market in Norway is however small compared to the housing market. In 2015, 82 percent of the population in Norway lived in owner-occupied dwellings (SSB, 2015a). I will therefore limit my analysis to only focusing on the housing market.

The time horizon for my analysis is set from the first quarter of 2000 to the fourth quarter of 2016. The housing market in Norway experienced a plunge in 1992, but since then there has been a continuous increase in housing prices, with an exception of a small decline in 2008 due to the financial crisis. I want to investigate if there are indications of a potential housing bubble in the housing market in Oslo today, and I therefore find this time horizon fitting for my analysis. A longer data set would probably yield a more robust result, but due to limited data availability for the housing market in Oslo, it was not possible to retrieve data sets that go longer back in time. This will be further elaborated on in the following section “Methodology and data”.

2.0. Methodology and data

The main objective for writing this thesis is to analyze what drives the price development in the housing market in Oslo in order to answer the following question; “Are there indications pointing towards a bubble in the housing market in Oslo?”. In order to draw well-founded conclusions, it is essential to obtain reliable information with high validity. In this chapter, I will present and discuss the methodology and data used in this dissertation.

This dissertation uses an ontological framework based on a post-positivistic approach. According to Guba (1990), the post-positivistic ontology assumes an objective reality, but acknowledge that the reality can be perceived only imperfectly and probabilistically as individuals constitute imperfect intellective mechanisms. In practice, this means that the findings of the analysis most likely are true, however always subjected to falsification (Guba & Lincoln, 1994).

The approach of this dissertation is deductive. According to Bryman (2012) the researcher tests a hypothesis deducted on the basis of what is known about in a particular domain and of theoretical considerations in relation to that domain by using empirical data in a deductive approach. In this dissertation, I am developing a house price model derived from well-founded theories and previous research in order to test whether there are indications of a bubble in the housing market in Oslo. Hence, I am testing a hypothesis by using specific theory and obtained empirical data. The method used in this thesis can be further described as exploratory, as I am investigating the problem statement by developing a new house price model for accessing house prices in Oslo.

In order to answer the research question, theory and empirical data will be combined in an analytical assessment of movements in the housing market in Oslo. Both quantitative and qualitative research will be applied, with an emphasis on quantitative research. By conducting a regression analysis on fundamental factors, the goal is to explain the development of housing prices in Oslo. If the analysis turns out to explain little of the development in house prices, this is an indication of a potential housing bubble in the market.

The data applied in this dissertation are secondary data, and consist primarily of online resources, journals, books, and data from statistic banks. The main advantage of secondary data is that it is relatively easy to retrieve and therefore is timesaving. The fields of real estate economics and housing bubbles are both well covered in the literature, and there exists countless academic articles and research on these topics. This makes it easy to gather data from experts and scholars in this area. Further, SSB makes historical data on economic factors for Norway easy to retrieve, being a well-established and updated data bank. The main disadvantage with secondary data is that the process of gathering the data has been conducted with a different objective in mind, and the appropriateness of the data therefore need to be questioned. Further, lack of control over the data retrieved makes it important to verify the quality of the data.

Data validity is essential in order to draw well-founded conclusions. When the research is mainly quantitative the validity and reliability of the data is especially important. The data used in this thesis is primarily obtained from NCB and SSB. These are both considered to be reliable sources. I do therefore consider the validity of the data used to be good. When it comes to the appropriateness of the data I have made sure to only use data that is relevant to the problem statement. The main difficulty with obtaining appropriate data for the analysis has been that much of the historical data published by SSB covers Norway as a whole, and are not specific for Oslo. I have therefore decided to use quarterly data from 2000 to 2016 in my analysis. A longer data set would probably yield a more robust result, but due to data limitations it was therefore not possible to retrieve data sets that go longer back in time. As I am studying price development in recent time I do however find this date set appropriate.

3.0. Real estate economics and the theoretical foundation of house price development

The purpose of this chapter is to describe the theoretical foundation of house price determination, and to identify some of the most important fundamental factors driving housing supply and housing demand.

3.1. An introduction to real estate economics

The focus in the field of real estate economics is on understanding the demand and supply dynamics, and how changes in exogeneous variables drive the price development in the real estate market. This field of study tries to explain, describe, and predict real estate prices by applying economic techniques. In addition, an important aspect of real estate economics is to investigate the effect of government regulation on the price development in the real estate market (Harman, 2012).

The real estate market is distinguished from other markets with some unique characteristics, making the real estate market a difficult market to analyze.

Real estate is a durable good. A building can last for centuries, and land has no expiration date. The real estate market can therefore be described as a stock-flow market, where the stock of real estate supply in a given period can be described as the sum of the housing stock in the previous period, depreciation of the current housing stock, and the flow of new housing construction in the period. The construction of new housing takes time, leading to an inelastic supply in the short run, and the market adjustment process is therefore restricted by a time delay (Harman, 2012).

Further, real estate is a heterogeneous good, where all dwellings are unique when it comes to structural and locational characteristics (Harman, 2012). When households buy a dwelling they also "buy" the location. Traveling to work or different service offers, cost both money and time, and consumers will therefore pay more to reduce these costs (Fallis, 1985). This makes the pricing of real estate property more difficult. The most common approach to get around this problem in the literature, is to define supply in terms of service units (Harman, 2012). Behind this definition lies an assumption stating that the price per unit of housing services is the same for all dwellings. Number of housing services provided by a dwelling is decided based on the market rent for that dwelling. In that way, the price of real estate can be calculated based on homogenous housing services (Fallis, 1985). This approach will not be useful to answer all research questions, especially not on the microeconomic level, but it has however proven useful when analyzing the market on an aggregated level.

Furthermore, the real estate market is characterized with imperfections due to high transaction costs and illiquidity. Buying real estate property cost much more than other types of transactions, both when it comes to search costs and transaction fees. These extra costs and the extra time needed to search for potential buyers further makes real estate illiquid, where illiquid here is defined as the inability to make a quick sale for the full price. Real estate investments also differ from stock investments in that no short sales are allowed on direct real estate investment (Liu, Grissom & Hartzell, 1990).

Real estate economics can be divided into research on the microeconomic and the macroeconomic level. Research with a microeconomic perspective focuses on the heterogenous character of housing, where structural and locational characteristics are important factors determining housing prices. This research is closely related to the field of urban economics, with a focus on research allocation in a spatial context. Research with a macroeconomic perspective on the other hand focuses on the aggregated supply and demand in the market, where all dwellings are assumed to respond similar to changes in fundamental factors (Fallis, 1985). The analysis in this thesis will be based on the macroeconomic perspective and housing will therefore be considered a homogenous good that react similar to changes in underlying fundamental factors.

The real estate market can further be divided into the market for commercial real estate and the market for residential real estate (Harman, 2012). The residential real estate market, in this thesis referred to as the housing market, is the market for residential dwellings such as apartments, houses and vacation homes. The market for commercial real estate refers to property with other purposes, such as office buildings and hotels. Housing demand differs from commercial real estate demand on three aspects. First, it is considered a necessity with strong social and political undertones. Second, housing makes up most of most homeowner's wealth. Third, housing is more often a consumption good than an investment instruments (even though the latter is always present) (Pirounakis, 2013). In this thesis, I will solely focus on the housing market in my analysis.

3.2. A theoretical framework explaining house-price dynamics

The housing market is a complex market and the purchase and sale of housing is a process that is affected by many different factors. On an overarching level, the housing market can however be divided into housing supply and housing demand, and the housing market can be analyzed in a simple supply and demand model. I will here present a theoretical framework explaining the supply and demand dynamics in the housing market, both in the short and the long term. The theory in this section is mainly based on the work of Pirouinakis (2013) and Jacobsen & Naug (2004). Further, Tobin's q theory is presented in order to provide an understanding of residential investment.

3.2.1. An aggregated function of housing demand

Housing demand consist of two different types of buyers; people who are buying dwellings as a consumption good and people who are buying dwellings as a pure investment instrument. It is reasonable to assume that the majority of buyers in the housing market buy dwellings as a consumption good (Jacobsen & Naug, 2004). I will therefore focus on owner-occupied demand in my analysis, and I will further assume that this demand is proportional to the total housing demand in the market.

The Housing demand can be described with the following aggregated function of demand:

$$(3.1)\quad \mathrm{H^D} = \mathrm{f}\left(\frac{\mathrm{V}}{\mathrm{P}}, \frac{\mathrm{V}}{\mathrm{HL}}, \mathrm{Y}, \mathrm{X}\right), \qquad \frac{\partial \mathrm{f}}{\partial\left(\frac{\mathrm{V}}{\mathrm{P}}\right)} < 0\,, \ \frac{\partial \mathrm{f}}{\partial\left(\frac{\mathrm{V}}{\mathrm{HL}}\right)} < 0, \ \frac{\partial \mathrm{f}}{\partial \mathrm{Y}} > 0 \quad \text{Where,}$$

H^D = Housing demand, V = total housing costs for a typical owner (the user cost of housing), P = index of prices for goods and services other than housing (CPI), HL = total housing costs for a typical tenant (rent), Y = household's real disposable income, X = a vector of other fundamentals that affect housing demand.

This equation states that housing demand is a function of housing costs, household's real disposable income, and a vector X that describes other fundamental factors that affect housing demand. Looking at the partial derivative of equation (3.1), we see that an increase in real disposable income will result in a higher housing demand, while an increase in housing costs in relation to the price of other goods and services or in relation to rent, will result in a decreasing housing demand.

In order to get a better understanding of housing demand, the three different factors in equation (3.1) will now be elaborated on below.

<u>The user cost of housing</u>

Housing costs describes the costs a home owner forgo by owning and occupying a dwelling for a period of time (Jacobsen & Naug, 2004). In the literature, we find two approaches to calculate the user cost of housing, one that look at the utility maximization of households, and one that look at homeowners as profit maximizing landlords that "save rent" by owning rather than renting a dwelling. The intuition is different, but both approaches yield the same result (Dougherty & Order, 1982).

I will here present a popularly cited "imputed rent" model developed by Himmelberg, Mayer and Sinai (2005) in order to get a more thorough understanding of which factors affect housing costs. The intuition behind this model is that the financial return associated with owning a dwelling can be calculated by comparing what it would have cost to rent a comparable dwelling (imputed rent) with the lost income an alternative investment would have generated (the opportunity costs of capital) . [2]

The annual user cost can be described with the following equation:

$$\text{(3.2)}\ \ \text{Annual cost of ownership} = P_t {r_t}^{r_f} + P_t\omega_t - P_t\tau_t({r_t}^m + \omega_t) + P_t\delta_t - P_t g_{t+1} + P_t\gamma_t$$

This equation consists of six components[3], including both costs and offsetting benefits with owner-occupation. The first component represents the cost of forgone interest rate (the opportunity costs of capital). The second component represents the one-year cost of property taxes. The third component represents tax benefits of owner-occupation, calculated as effective tax rate on income times estimated mortgage and property tax payment. The fourth component represent maintenance costs as a fraction δ of the home value. The fifth component represent the expected capital gain. The sixth and last component represent the higher risk associated with owning vs. renting a dwelling.

As stated by equation (3.2) a lower real interest rate, property tax, maintenance costs, and associated risk, will all result in a lower cost of ownership. Lower tax benefits and expectations about future price increases will on the other hand result in a higher cost of ownership. The interest rate has a direct effect on housing costs through mortgage expenses, and an indirect effect through lost interest income (the opportunity cost of capital). Further, expectations about future prices increases has a direct effect on housing wealth, and an indirect effect on housing costs as it gets relatively more advantageous to own rather than to rent a dwelling (Jabobsen & Naug, 2004).

Equation (3.1) and (3.2) are here describing owner-occupied demand. The variables in both equations will however also affect demand for housing as an investment instrument. Lower rent and/or higher expected rise in house prices will make it more beneficial to invest and rent out the dwelling than to keep money in the bank. The demand for housing as an investment instrument will therefore react similarly to changes in factors as

[2] Limitations to this model is that it is based on simplifications such as zero transaction costs, static expectations regarding inflation, interest and tax, and equal after-tax returns for debt and equity (Hendershott & Slemrod, 1982).
[3] This distinction is further supported by other scholars, see e.g. Poterba (1984) and Hendershott & Slemrod (1982).

owner-occupied demand (Jacobsen & Naug, 2004). This support the hypothesis that owner-occupied demand is proportional with the total housing demand in the market.

Real disposable income

Assuming that housing is a normal good, an increase in real disposable income will result in a higher housing demand. An increase in real disposable income makes it possible to invest more in housing, while still being able to consume the same amount of other goods and services. The overall willingness to pay in the housing market will therefore increase.

The X vector

The X vector in function (3.1) includes other fundamental factors that affect housing demand, and should incorporate effects from factors such as demographic conditions, bank's lending policies and household expectations concerning future income and housing costs (Jacobsen & Naug, 2004).

Total demand in the market depend on demographic conditions such as population growth and population movements such as net-migration (Jacobsen & Naug, 2004). Other important demographic conditions, are increased life expectancy, number of people in the start-up phase, and urbanization trends. Housing demand is further dampened or amplified by the household composition, where number of people per household is an important factor determining the demand in an area (Larsen & Sommervoll, 2003). These factors will both affect the regional housing prices and the total average in the market (Jacobsen & Naug, 2004).

Bank's lending policies are important since most households raise loans to finance the purchase of housing (Jacobsen & Naug, 2004). The lending policies of banks depend on the expected ability of lenders to repay their debt. These expectations are closely related to future outlooks in the labor market and the economic situation in the country. We can therefore expect a higher supply of credit in a boom period in the economy (Larsen & Sommervoll, 2003). Other factors that affect bank's lending policies are profitability and government regulations (Jacobsen & Naug, 2004). Strict credit restrictions may work as an obstacle for people to enter the housing market, while too loose credit restrictions may induce inflated prices in the market (Larsen & Sommervoll, 2003).

Future expectations concerning income and housing costs are important, as changes in these variables can have huge implications for households. Housing is a consumer durable, the purchase of housing is the most substantial purchase for most households, and most household's debt-finance a substantial portion of the purchase price. A decrease in real disposable income or an increase in housing costs will therefore have a huge impact on household's consumption of other goods and services (Jacobsen & Naug, 2004). Further, expectations about the price development in the housing market is important as a decrease in housing prices will greatly affect the household wealth. Excessive expectations about future price increases followed by a drastic downward adjustment of expectations in the future will result in a negative shift in the housing demand, resulting in a rapid price fall in housing prices (Shiller, 2003).

3.2.2. The housing stock and residential investment

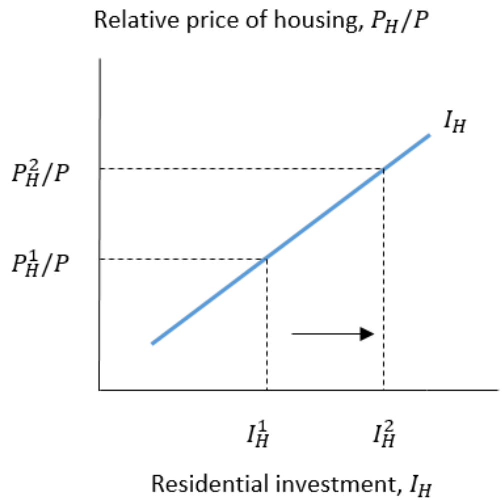
Housing supply, measured by the housing stock, can be described with the following equation:

(3.3) $H^S = S_t = S_{t-1} + C_t - \delta S_t$ Where,

H^S = Housing supply, S_t = Current housing stock, S_{t-1} = Housing stock in the previous period, C_t = New housing construction, δS_t = Depreciation of current housing stock.

As explained above, the housing market can be described as a stock-flow market. There is a time lag in housing construction as it takes time to build new housing and housing construction is low compared to total housing stock. Further, it takes time to wear out the current housing stock. The housing stock can therefore be assumed to be stable in the short term. Over time, however, we can expect housing supply to adapt to housing demand in the market through new housing construction (Jacobsen & Naug, Mishkin 2004/2012). Understanding what drives residential investment is therefore important to understand the dynamics of housing supply and the long-term price development in the housing market.

Figure 3.1. Residential investment curve



(Figure taken from Mishkin, 2012)

Figure 3.1. illustrates the residential investment curve. As we can see from the curve, residential investment is an increasing function of the relative housing price. A higher relative housing price leads to a higher level of housing construction in the market. A popularly used theory to explain this relationship in the literature, is Tobin's q theory (Anundsen, 2013). James Tobin and William C. Brainard initially developed this theory for investment in the asset market when it was introduced in 1968, but it has later been applied to explain investment in the housing market (Mishkin, 2012). Illustrating Tobin's q for the housing market:

$$(3.4)\ q = \frac{Market\ value\ of\ house}{replacement\ cost} = the\ relative\ house\ price = P_H/P$$

Simply explained, this theory assumes that the level of residential investment is a positive function of the ratio of market price of existing houses to replacement cost, where replacement cost here is construction costs. Looking at the equation above, new dwellings will be built if q > 1 (Grimes & Aitken, 2010). As construction cost follows the market fluctuations, we can therefore expect housing construction to follow the business cycle (Mishkin, 2012).

The reason why Tobin's q theory is popularly used to explain residential investment is probably because of its intuitive and solid theoretical foundation. This approach has however proven less successful empirically (Grimes & Aitken, 2010). Mayer and Somerville (2000) argues that residential investment cannot be treated like other types of investment as supply of land is inelastic also in the long-term. When studying urban areas with limited availability of land, an increase in demand will automatically result in a permanent increase in land prices, which will further drive house prices up. Excluding land prices in the model for residential investment will therefore yield a biased result.

In today's society where people are gathering more and more in urban hot-spots, there has developed a willingness to pay a much higher price to live centrally located in the city center (Larsen, 2005). An implication of this is that housing construction outside the city center may actually lead to higher housing prices in the center, instead of decreasing prices as predicted by the supply and demand theory. Centrally located dwellings get relatively more attractive due to their location, and prices will therefore continue to increase even though the supply of housing is increasing. Regulatory restrictions that create barriers for housing construction in the city center may therefore have a strong impact on house price development in urban areas (Glaeser, Gyourko & Saks, 2005).

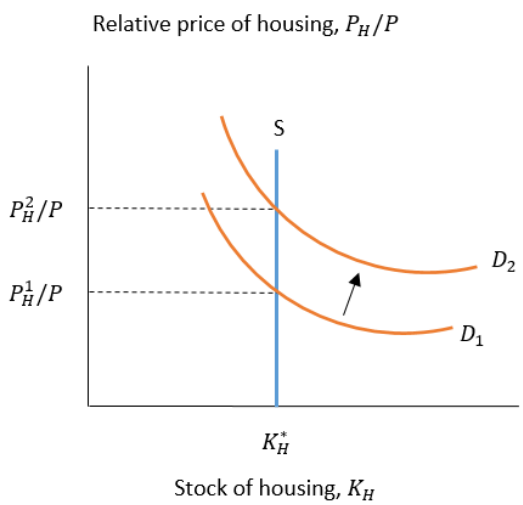
3.2.3. Short- and long-term equilibrium in the housing market

Figure 3.2. below illustrates the supply and demand dynamics in the short term. The equilibrium price in the short term can be explained with the following equation:

$$(3.5)\ \ H^D = f(\frac{V}{P}, \frac{V}{HL}, Y, X) = H^S$$

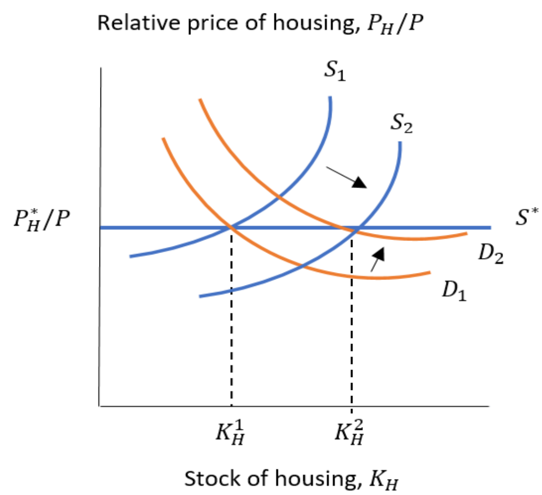
As the supply is inelastic in the short term, any stimulus resulting in a shift to the right in the demand curve will therefore result in a higher equilibrium price in the market. The immediate short-term result of an increase in real disposable income would therefore be a simultaneous increase in the relative price of housing (Kenny, 1998). In the short-term, we can therefore expect a higher degree of fluctuations in the equilibrium price (Jacobsen & Naug, 2004). The long-term equilibrium in the housing market, where housing construction is taken into consideration, is illustrated in figure 3.3. below. The horizontal line illustrates a scenario where the long-term supply is perfectly elastic. Under this scenario, the price is fixed at P_H^*, approximately the same as construction costs. There is no long-term effect on the relative housing price of a shift to the right in the demand curve, however the housing demand determines the quantity supplied in the market. This scenario illustrates a perfectly competitive market where costs are variable, and there are no barriers to entry (Kenny, 1998). As discussed under the housing supply section, land costs are inelastic also in the long-term when there is a fixed supply of land, so in most cases it would be a simplification to assume perfectly elastic long-term supply. The two upward sloping supply curves illustrates a situation where the supply elasticity is positive but not perfectly elastic in the long-term. Under this scenario, we see a simultaneous shift in housing demand and housing supply. Higher relative housing prices due to increased demand results in a higher level of housing construction, as it gets relatively more profitable to supply more dwellings (Kenny, 1998). A higher level of housing supply will put a downward pressure on the housing prices over time. This effect would be further strengthened if the increased level of housing construction would happen simulations as a decreasing level of demand (Jacobsen & Naug, 2004).

Figure 3.2. Supply and demand short term



(Figure taken from Kenny, 1998)

Figure 3.3. Supply and demand long term



(Figure based on figure from Kenny, 1998)

4.0. Bubble theory

The purpose of this chapter is to define a bubble and to introduce a theoretical framework for explaining the emergence of bubbles. Further, the two main approaches to measure a housing bubble found in the literature will be discussed, addressing strengths and weaknesses of both approaches.

4.1. Defining a bubble

There has so far not emerged a uniform definition of a bubble in the literature. The term bubble is popularly used, but seldom clearly defined (Case & Shiller, 2004). There are many different explanations of what causes a bubble, and conflicting views about whether there is or has been a bubble in a certain market may often stem from different definitions of a bubble (Lind, 2008). The most common understanding is however that bubbles are situations in which the price of assets exceeds their fundamental value (Joebges, Dullien, & Marquez-Velazquez, 2015). When prices later decline to what can be justified by fundamental value, the bubble bursts (Grover & Grover, 2014).

According to Krakstad & Outs (2015) there are two main types of bubble definitions in the literature; the normative type and the descriptive type[4]. The most commonly cited normative definition in resent bubble literature is the one by Nobel Prize winner Joseph E. Stiglitz. He defines a bubble as:

“If the reason that the price is high today is only because investors believe that the selling price will be high tomorrow—when "fundamental" factors do not seem to justify such a price—then a bubble exists” (Stiglitz, 1990, p.13).

This definition can be understood as a situation where some buyers are willing to pay a higher price for an asset than can be justified by its fundamental value because they expect further price increases in the future[5] (Joebges, Dullien, & Marquez-Velazquez, 2015). This can be explained as a feedback loop, where initial price increases in a market generate expectations about further price increases. The gain of some investors creates a momentum which further attracts new investors, leading to an increased demand in the market (Shiller, 2003/2005).

Lind (2008) criticizes the definition above. He argues that a bubble definition should explain a full bubble episode – both a price increase and a price decline. Only focusing on price increases is not sufficient to define a bubble. Further, Lind are skeptical about the vagueness of the definition, as fundamental factors are not precisely defined. Scholars and experts are not uniform in their definition of fundamental factors, and subjective judgements may therefore open up for different interpretations. His solution to this problem is to define a bubble solely based on development of prices, and not based on the reason behind this price development. Lind’s definition is an example of the descriptive type and defines a bubble as follows:

“There is a bubble if the (real) price of an asset first increase dramatically over a period of several months or years and then almost immediately falls dramatically” (Lind, 2008, p. 80).

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[4] This distinction is further supported in the work of Mayer (2011).

[5] Similar definitions have been developed by other acknowledged economists, including Case & Shiller (2004) and Kindleberger (1987).

Lind's definition is addressing two important issues when it comes to identifying a bubble. First, that it is very difficult (some might say impossible) to identify a bubble in present time. It is only possible to say with complete certainty ex-post whether or not a price run-up in a market is a bubble, or if it is a result of development in underlying fundamental factors (Bradley, 2015). Further, an asset may be overpriced without there being a bubble in the market, where overpriced here is defined as a deviation from the equilibrium price (Krakstad & Outs, 2015). One reason for this could be imperfections in the market. Another reason could be market regulations and policies, imposing restrictions and time lags on the market. A market correction with a corresponding slow-down in price increases may stabilize the market, and a dramatic fall in prices may therefore not be the result. Secondly, the empirical application of a bubble is complicated. The fundamental value of an asset cannot be observed in the market and therefore has to be calculated based on an economic model. Calculating the fundamental value of assets is not straightforward, and there is no theoretical consensus in the literature on how this value should be calculated (Joebges, Dullien, & Marquez-Velazquez, 2015).

4.1.1. A theoretical framework explaining the emergence of bubbles

One of the reasons why there are conflicting views about what causes bubbles is that the emergence of a bubble is a complex phenomenon, and depend on the interaction of several different factors (Kubicova, & Komarek, 2011). Only focusing on buyer expectations about future price increases is therefore not sufficient to fully explain the emergence of bubbles, and a broader theoretical framework is necessary (Lind, 2008). By reviewing the bubble literature, I will here present a theoretical framework to explain the emergence of bubbles[6].

According to Pirounakis (2013) there are three necessary conditions that need to be present for a bubble to exist. First, there need to be fundamental factors, like income increases- causing a rise in demand in excess of rise in supply. Secondly, there need to be a rise in buyer's budget constraint, either as a result of an inflow of cash or due to easy access to credit. Thirdly, there need to be a widespread preference in the market for investing in a specific asset or asset class.

[6] In the bubble literature, four main categories of models explaining the development of bubbles has emerged. Rational bubbles under symmetric information, rational bubbles under asymmetric information, irrational bubbles due to behavioral traders and limits to arbitrage, and irrational bubbles due to psychological biases (heterogeneous beliefs bubbles). Discussing these different models is outside the scope of this thesis, but interested readers are referred to Brunnermeier (2008).

The importance of credit availability for the development of bubbles is emphasized by many scholars. In his book "Manias, Panics and Crashes", Charles P. Kindleberger argues that bubbles result from procyclical changes in the supply of credit (Kindleberger & Aliber, 2005). Brunnermeier & Schnabel (2014) find historical evidence suggesting that both lending booms and capital inflows often precede or follow the emergence of bubbles. This is further emphasized by a broad consensus stating that the primary cause for the US recession in 2008 was relaxed standards for mortgage loans leading to a burst in the housing market (Holt, 2009). Other scholars argue that the opportunity to borrow creates a principal-agent problem, where assets are valued higher than their fundamental value due to a perceived lower risk, causing risk-shifting to emerge in the market (Allen & Gale, 2000). Further, evidence suggest that the probability of a crisis is higher when bubble tendencies in the market correspond with high household debt (Anundsen, Gerdrup, Hansen & Kragh-Sørensen, 2016). Evidence from the housing bubble in Spain following the economic recession in 2008, also show that high debt increases the scope of the crisis, and extend the timeframe of the crisis (Carballo-Cruz, 2011).

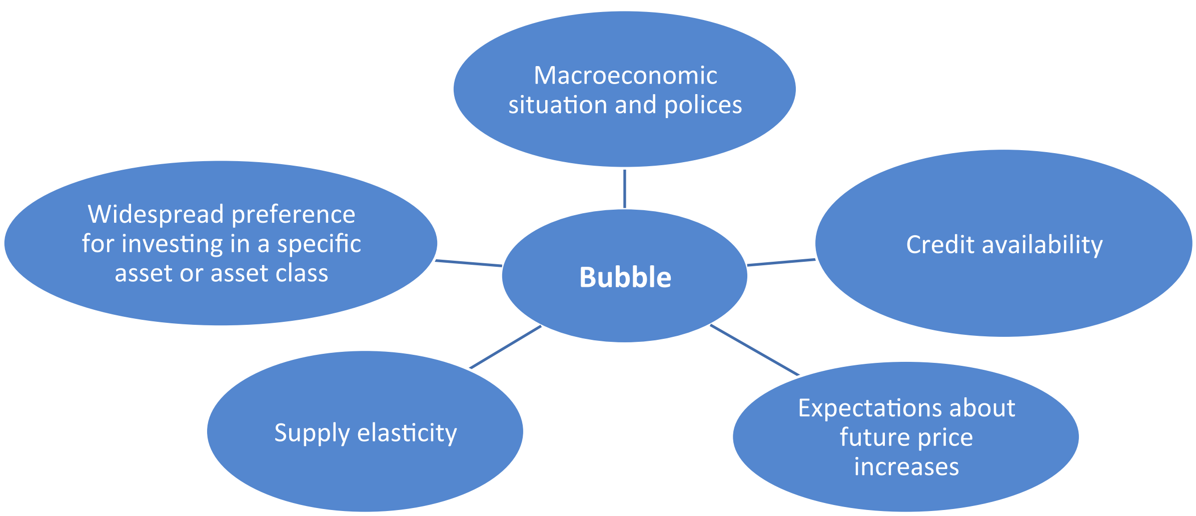
The macroeconomic situation and macroeconomic policies are other important conditions for the development of bubbles. A bubble typically starts in a boom period in the economy, where macroeconomic factors such as low unemployment and economic growth, drives the demand in the market (Lind, 2008). Further, evidence suggest that an expansive monetary policy may boost a bubble in its growing phase. This is typically an issue if the inflation is low and the central bank is narrowly following an inflation-target strategy. Whether central banks should use monetary policy as a mean to prevent bubbles is, however a heated debate between economists, and no consensus has so far emerged in the literature (Evanoff, Kaufman & Malliaris, 2012). Some economists also argue that fiscal policy act as an amplifier for the development of bubbles. McDonald & Stokes (2015) found evidence in their study suggesting that both monetary policy and fiscal policy were causes of the large increase and following crash in US housing prices during the 2000-2010 decade.

In the behavioral branch of the bubble literature, herd behavior is emphasized as an important factor for the emergence of bubbles by many economists. Herd behavior is here referred to a situation where the decision to invest in an asset is solely based on the investment of others, and not based on an analysis of the asset's fundamental value (Joebges, Dullien, & Marquez-Velazquez, 2015). Herd behavior and over-confidence among investors may lead to a positive feed-back loop in the market, leading to a widespread preference for investing in a specific asset or asset class in the market (Zhou & Sornette, 2006). In addition, the media is emphasized as an important factor that might fuel a boom period by creating a hype and increased enthusiasm in the market (Rapp, 2015).

The importance of understanding the supply side of the bubble development has been more and more emphasized by scholars in resent time (Gyourko, 2009). Glaeser, Gyorko & Saiz (2008) argues for how housing supply must be incorporated in the analysis to fully understand a boom-bust housing cycle. In their paper "Housing Supply and Housing Bubbles", they find that in places with elastic housing supply the emergence of bubbles are more seldom, and bubbles are shorter in time-horizon. Their evidence does however indicate that there is also a downside to elastic supply as they find that in places with elastic supply, overbuilding in reaction to the bubble may lead to higher welfare consequences when the bubble burst. The importance of supply elasticity on house price development is further supported by Ihlanfeldt & Mayock (2014) who find in their study that supply elasticity can explain much of the different price movements in local markets in Florida. They further argue that difference in supply elasticity can be attributed to local differences in fiscal and regulatory environment, in addition to local differences in land availability.

Summing up, a theoretical framework explaining the emergence of bubbles can look something like this:

Figure 4.1. A theoretical framework explaining the emergence of bubbles



(Source: This model is inspired by the theoretical framework developed in Lind (2008))

In this dissertation, I will base my definition of a housing bubble on the theoretical framework developed above, in addition to Stiglitz' definition of a bubble. As a bubble cannot be fully identified before it bursts, I will emphasize that my goal is not identify a current housing bubble in the market. My goal is to analyze if housing prices seem overvalued compared to underlying fundamental factors in order to evaluate if we see *signs* of a potential bubble in the housing market in Oslo.

4.2. Different approaches to measure housing bubbles

The different approaches to measure housing bubbles generally compares the observed price (actual price) with some indicator of fundamental price (theoretical price) in order to assess if prices seem overvalued (Bourassa, Hoesli, & Oikarinen, 2015). The problem of measuring a housing bubble is how to appropriately measure the fundamental value of housing. In the literature, there has developed two main approaches to measure the fundamental value of housing, a finance-based approach and an econometric approach. The finance-based approach calculates the fundamental value based on the asset present value method, while the econometric approach measures the fundamental value based on economic fundamentals (Jia & Li, 2014). These approaches will be compared below, looking at strengths and weaknesses of both approaches.

4.2.1. The finance-based approach to measure housing bubbles

The finance-based approach to measure a housing bubble sees housing as an investment, and tries to measure the fundamental value of a house by discounting its future expected earnings (Jia & Li, 2014). This approach is closely related to the dividend discount model, and has a solid theoretical foundation. In the simplest form, this approach tries to identify housing bubbles by comparing ratios such as price-to-rent and price-to-income with their long-term averages (Bourassa, Hoesli, & Oikarinen, 2015). The price-to-rent ratio intend to reflect the relative cost of owing compared to renting, while the price-to-income ratio intend to reflect housing cost relative to buyer's ability to pay (Himmelberg, Mayer & Sinai, 2005). The intuition is that if these ratios exceeds their long-term average, this is an indication of a housing bubble in the market (Grytten, 2009a). Jacobsen & Naug (2004) do however argue that these ratios are incomplete, as they do not measure whether house prices are high compared to rent or income due to a bubble, or due to development in fundamental factors. Further, these ratios have been found unreliable to identify bubbles under certain conditions. Himmelberg, Mayer & Sinai (2005) find that these ratios can be misleading, as they do not to account for either time series pattern of real long-term interest rates, nor predictable differences in the long-run growth rates of house prices across local markets. This is further supported by Joebges, Dullien, & Marquez-Velazquez (2015), who argues for how changes in these ratios only works as indicators of a housing bubble in times when expectations about nominal long-term interest rates and the long-term rate of inflation are constant. More advanced studies do however incorporate more factors when determining the fundamental value of owner-occupied housing, in addition to rental savings or income, and often incorporates regression analysis in the study[7]. According to Smith & Smith (2006) it is important to look at every factor that affect the cash flow, such as: transaction costs, property taxes, maintenance costs, tax savings, mortgage payments, insurance, and profit if the house is sold, when trying to calculate the fundamental value of a house. Only when all factors affecting the cash flow is incorporated, the projected cash flow can be discounted by the prospective buyer's required rate of return. As not all of these factors are easily observable in the market, this makes present value models computational complex. A downside with the present value approach is therefore that it is difficult to apply in practice (Bourassa, Hoesli, & Oikarinen, 2015).

4.2.2. The econometric approach to measure housing bubbles

The econometric approach to measure housing bubbles tries to explain development of house prices by studying underlying fundamental factors in the market. This is usually done by conducting a regression analysis or a cointegration test on various supply and demand factors (Bourassa, Hoesli, & Oikarinen, 2015). The intuition behind this approach is that the equilibrium price (the theoretical price) in the market is the price at which the quantity supplied equals the quantity demanded. If supply and demand factors explain little of the development in house prices, this is an indication of a potential housing bubble in the market (Jacobsen & Naug, 2004). Joebges, Dullien, & Marquez-Velazquez (2015) do however find that most of the empirical studies conducted in this area have neglected to define the fundamental value of housing. Further, they also find that the fundamental factors included in the analysis not always are derived from a theoretical foundation. This is further supported by Bourassa, Hoesli & Oikarinen (2015), who argues that some of these models are based on economic theory, but often the explanatory factors are chosen more ad hoc. One of the reasons for this can be that there has not emerged a uniform definition of fundamentals (Lind, 2008), and researches may use their subjective judgement when deciding on factors to analyze. One of the problems with this is as that it makes it difficult to compare different studies, and different conclusions may develop due to different definitions of fundamentals (Lind, 2008). Another issue with this approach, pointed out by Bourassa, Hoesli & Oikarinen (2015) is that some of the fundamental factors explaining housing prices may not explain the long-term equilibrium price, because they tend to be mean-reverting in nature, which may result in a biased result from the analysis. Further, biased conclusions may emerge if the studied data do not include all the relevant fundamental factors (Anundsen, 2016). The econometric approach is however less computational complex

[7] See e.g. McCarthy and Peach (2004)

than the present value approach, and is therefore easier to apply in practice (Bourassa, Hoesli, & Oikarinen, 2015).

5.0. Earlier studies

This chapter will present some earlier studies that have investigated similar relationships that I am doing in this dissertation. The purpose is to investigate what the most important fundamental explanatory factors for house price development are, and to provide the reader with a short description of some previously developed house price models.

5.1. Jacobsen & Naug (2004)

In their paper "what drives house prices", Jacobsen and Naug investigates the key drivers of house prices in Norway on quarterly data from 1990 to 2004. The aim of this paper is to figure out what the most important fundamental explanatory factors for house prices are, and to investigate how quickly and strongly house prices react to changes in these factors. Further, they want to investigate whether house prices are overvalued compared to fundamentals. After testing for several factors that might drive the price development in an error correction model, they find that; unemployment, interest after tax, housing construction, income, and expectations about own and the Norwegian economy are the most important explanatory factors for housing prices in the Norwegian market.

Jacobsen and Naug's house price model is expressed as follows:

(1) $\Delta houseprice_t = \beta_1 \Delta income_t + \beta_2 \Delta(INTEREST(1-\tau))_t + \beta_3 \Delta(INTEREST(1-\tau))_{t-1} + \beta_4 EXPEC_t - \lambda \left[houseprice_{t-1} - \delta_1 \left(INTEREST(1-\tau)\right)_{t-1} - \delta_2 unemployment_t - \delta_3 (income - housingstock)_{t-1}\right] + \alpha + \beta_5 S1 + \beta_6 S2 + \beta_7 S3$

(2) $EXPEC = (E-F) + 100(E-F)^3$

(3) $\Delta E_t = \alpha + \gamma_1 \Delta(INTEREST(1-\tau))_t + \gamma_2 \Delta unemployment_t + \gamma_3 E_{t-1} + \gamma_4 INTEREST(1-\tau)_{t-1} + \gamma_5 unemployment_{t-1} + \gamma_6 S1 + \gamma_7 S2 + \gamma_8 S3 + \varepsilon_t$

Where: $houseprice$ is the price index for resale homes, $INTEREST$ is Bank's average lending rate, τ is marginal tax rate on capital income and expenses, E is the indicator of household expectations concerning their own financial situation and the Norwegian economy (measured as rate, total over two quarters), F is the value of E that may be explained by developments in the interest rate and unemployment, $unemployment$ is the unemployment rate, $income$ is total wage income in the economy, $housingstock$ is housing stock at constant prices, and Si is a variable which is equal to 1 in quarter i, otherwise zero. Δ is the difference operator, and small letters indicate that variables are measured on a logarithmic scale.

Jacobsen and Naug argues for how the indicator of household expectations concerning their own financial situation and the Norwegian economy is highly correlated with the growth in interest and unemployment. In order to correct for multicollinearity in their model Jacobsen and Naug are therefore running a regression of expectations on interest and unemployment, see equation (2) above. Thereafter the difference between estimated and actual value, which now is an unbiased estimate of changes in expectations (not induced by interest nor unemployment), are used in their specified model for expectations. See equation (3) above. This model for expectation estimation is not explained by Jacobsen and Naug in their paper and I can only guess that it is used as a mean to account for a possible exponential effect of expectations on housing prices.

In their analysis Jacobsen and Naug found that house rents and other consumer prices generally had coefficients and t-values close to zero. Nominal interest rates showed a better fit than models with real interest rate, and the inclusion of inflation as a separate factor in models where nominal interest were used often resulted in inflation having the wrong sign. Further, they found no significant effect of household debt and no evidence that population movement or demographic factors have a strong direct impact on house prices. They do however point out that demographic conditions change slowly over time, and it can therefore be difficult to identify effects of demographic conditions in an econometric analysis over a relatively short time period. Their analysis further indicate that house prices react quickly and strongly to changes in interest rates, and that a fall in interest rates can explain much of the price inflation in the period from 2003. Jacobsen and Naug find no evidence that house prices are overvalued compared with a fundamental value determined by interest rates, income, unemployment and housing construction in the period of analysis. In their paper, they present both a model for nominal and real house prices and conclude that the model for nominal house prices has a better fit. The estimated model shows good explanatory power with an R squared of 87 percent.

5.2 Terrones & Otrok (2004)

Terrones and Otrok conducted a study for IMF in 2004, where they tried to identify the most important factors affecting house price fluctuations in industrial countries. Further, they investigated if house price fluctuations are mainly related to global factors or to country specific factors. The time period of the analysis was set from 1971 to 2003, and Terrones and Otrok used a dynamic factor model to investigate these questions for 18 industrial countries. In the model, the dependent variable is the growth rate of real house prices. The model postulates that the growth rate of real house prices in any given country and period is explained by the following factors: Past growth rate of real house prices, Past housing affordability ratio, and Economic fundamentals.

Terrones and Otrok's house price model is explained as follows:

- Past growth rate of real house prices: The idea behind this factor is that if the growth rate of house prices should be considered consistent, then the current growth rate must be serially correlated with the past growth rate (the lagged variable: growth rate of real house prices (-1)).
- Past housing affordability ratio: The affordability ratio is defined as the ratio of real house price (to per capita) real income. The idea behind this factor is that if the growth rate of house prices shows long-run version, then house prices should tend to fall when they are out of line relative to the income levels. The affordability ratio should therefore be negative.
- Economic fundamentals: This factor consist of economic variables that affect house price development and consist of real (per capita) disposable income growth, the short-term interest rate, growth in real credit, the lagged variable of real stock price growth, population growth and a dummy variable for the bank crisis.

In their analysis Terrones and Otrok found that real house prices in industrial countries show high persistence, in other words, they tend to rise tomorrow if they rise today. The growth rate of real house prices further shows fundamental reversion, meaning that if there is a misalignment between house prices and income this alignment will be gradually corrected. Furthermore, all of the fundamental factors are significant at the 1% level. All of the economic variables in the model therefore has a significant effect on house price development. The model is on average able to explain most of the increase in house prices during the period of analysis.

There are, however, country differences, and an important portion of the increase in Australia, Ireland, Spain and the UK, remains unexplained.

Terrones and Otrok further investigates if house price fluctuations are mainly related to global factors or to country specific factors. In their analysis, they found that global development on average explains 40 percent of house price movement, illustrating the importance of international linkages in house price development. Much of this global synchronized movements can be explained by developments in global interest rates and economic activity. An important implication of this result is that we should also expect the global house prices to be synchronized in case of a boom period. There are, however, big country differences. Global factors explain as much as 70 percent of house price movements in the US and the UK, but only 3 percent in New Zealand. This illustrates that whether we should focus on global or country specific factors in our analysis is highly dependent on the country of analysis. I Norway Terrones and Otrok find that about 75 percent of movement in house prices is explained by country specific factors. This result is very close to the result of Jacobsen and Naug (2004) of 87 percent.

5.3. Case & Shiller (2003)

In their paper "Is there a bubble in the housing market?" Case and Shiller investigates whether the boom in house prices in the US in 2003 are a bubble, and whether it is likely to burst or deflate. First, they analyze US state-level data on house prices and fundamentals on a quarterly basis in the period from 1985 to 2002. Second, they conduct a questionnaire survey in 2003 of people who bought homes in 2002 in the four metropolitan areas: Los Angeles, San Francisco, Boston and Milwaukee.

In order to investigate the relationship between house prices and other fundamental factors Case and Shiller performed linear and log-linear reduced form regressions with three dependent variables: the level of home prices, the quarter-to-quarter change in home prices, and the price-to-income ratio. The explanatory factors of analysis used were: Personal income per capita, Population, Employment, Unemployment rate, Housing starts, and Average mortgage interest rate. The result of their analysis showed that income growth alone could explain the pattern of recent home price increases in most states (all but eight). Including the other fundamental factors in these states added little explanatory power. In the eight states where income were a less powerful predictor, all the other fundamental factors added significantly to R squared. However, these eight states were experiencing declining price-to-income ratios and Case and Shiller therefore argues that the hypothesis that a bubble exist in these states cannot be rejected.

In the second part of their investigation, Case and Shiller sent out a questionnaire survey to 2000 people who bought homes between March and August 2002. The main idea behind this questionnaire survey was to investigate whether there was a bubble in the market by looking closer at the market characteristics. Case and Shiller defines a bubble in terms of people's thinking: *"Their expectations about future price increases, their theories about the risk of falling prices, and their worries about being priced out of the housing market in the future if they do not buy."* They therefore argue that seven market characteristics can indicate if there is a housing bubble in the market:

(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 it 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

In the result of the questionnaire survey Case and Shiller found elements of a speculative bubble. Especially they found that the strong investment motive, the high expectations of future price increases, and the strong influence of word-of-mouth exists in some states. However, put together with the econometric analysis, Case and Shiller found little evidence of a bubble in the US market.

5.4. Algieri (2013)

Algieri (2013) examined the key drivers of real house prices in five European countries (Germany, France, Italy, Spain, and the Netherlands) and the Anglo-Saxon economies (the United Kingdom and the United States) from 1970 to 2010 in her study. The aim of this study was to shed light on fundamentals and underlying factors that cause price fluctuations with the use of an error correction model. This model introduces, in addition to the traditional triggers of house prices, such as interest rate and disposable income, an unobserved component in the form of a time-varying trend. This unobserved component was introduced to pick up the stochastic unmodeled behavior of the time series due to underlying factors that are unknown, unobservable, unquantifiable, or not easy to compute[8].

Algerie's house price model is expressed as followed:

(1) $\Delta lnhp_t = \partial_1 lny_t + \partial_2 \Delta r_t + \partial_3 \Delta ln\pi_t + \partial_4 \Delta lnshare_t + \partial_5 \Delta lnpop_t + \partial_6 \Delta lngfcf_t - \gamma_1 lnhp_{t-1} + \gamma_2 lny_{t-1} + \gamma_3 r_{t-1} + \gamma_4 ln\pi_{t-1} + \gamma_5 lnshare_{t-1} + \gamma_6 lnpop_{t-1} + \gamma_7 lngfcf_{t-1} + \mu_t + \varepsilon_t$

(2) $\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t \quad \eta_t \approx NID(0, \sigma_\eta^2)$

(3) $\beta_t = \beta_{t-1} + \xi_t \quad \xi_t \approx NID(0, \sigma_\xi^2)$

Where: hp is the country's real house price, y is real income per capita, r denotes the real long-term interest rate, π is the inflation rate, $share$ is the stock market price, pop is population change, and $gfcf$ refers to residential investment. Δ is the difference operator and ln is the logarithm. The component, μ, reflect different phenomena embedded in house prices' trends and cycles. ε, η and ξ are normally distributed random disturbances (error terms) with means of zero and a constant variance, σ^2.

The estimated model shows a good explanatory power for all countries with an R squared between 56 and 78 percent. Further, the traditional model specification displays a lower R squared than the one with an unobserved variable. Algieri's analysis shows that house prices are positively driven by per capita income, stock prices, population changes, and inflation. House prices are negatively driven by interest rates and residential investment. Further, her analysis indicates that not all the price growth in resent time can be explained by changes in underlying fundamental factors. Algieri therefore argues that it remains crucial for regulators to closely monitor the housing market.

5.5. Krakstad & Oust (2015)

Krakstad and Oust (2015) examines whether housing prices in Oslo are overpriced compared to fundamental factors by applying the price-rent ratio, price-construction ratio and price-wages ratio for estimating equilibrium prices. The motivation behind their research is the high price growth seen in Oslo the last 20 years, and the period of analysis is set from 1970 to 2012. Krakstad and Oust develops a house price model derived

[8] E.g. the level of government intervention in the market, psychological factors or land use restrictions.

from the life cycle model[9], however they introduce another version where price is equal to a function of income, rent, and construction costs. Krakstad and Oust house price model can be explained as follows:

$$(1)\ \ p_h = \alpha_0 + \alpha_1 y + \alpha_2 p_{cc} + \alpha_3 r^{10}$$

Where: y=income, p_{cc}=construction costs and r=rent (all variables are on logarithmic scale)

The vector error correction model (VECM) is used to estimate equilibrium values of prices, rents, construction costs and wages. Further, the following short-term exogeneous variables are included; inflation, GDP per capita, unemployment rate, household consumption per capita, ten-year government bond interest rate, stock index returns, finished buildings, net immigration and population. All data are in real terms and on a yearly basis.

Krakstad and Oust find that the ratios price-rent, price-construction costs and price-wage are all able to explain developments in house prices. Rents and construction explain the long-run relationship, while wages are found weakly exogeneous, driving the other exogeneous variables in the long-run. The use of this estimation method does therefore seem like a good fit for this analysis. The result of the analysis indicates that housing prices in Oslo are overpriced with 35 percent. This does however not mean that there is a housing bubble in Oslo[11]. According to Krakstad and Oust, mush of this overpricing can be explained by a high demand due to factors such as low unemployment, high construction costs and low interest rates. Further, construction in Oslo has kept low due to high construction costs and a long list of building requirements.

5.6. Summary

The earlier house price studies described above clearly shows that there is no uniform model of studying house prices. The chosen approach and variables differ a great deal between the different studies, and clearly shows that there is not one particular model specification that is superior to others. The best approach chosen for a study depends on what the researcher want to investigate and the problem statement of the analysis. Despite a high degree of variations in approach and data, it do however seem to be a common agreement about the most important fundamental explanatory factors for house price development. Income, rent, construction

[9] In the traditional life cycle model, there is an equilibrium between house prices (p_h), disposable income(y), user cost of housing(uc) and housing stock(h) : $p_h = \alpha_1 y + \alpha_2 h + \alpha_3 uc$

[10] For a full derivation of the model transformation see Krakstad & Oust (2015)

[11] Ref. chapter 4.1. Defining a bubble.

costs and expectations are considered fundamental factors driving house price development in almost the entire sample of studies. Further, unemployment seem to be an important factor in most house price models. The choice between nominal and real variables differ greatly and it do not seem to be a consensus between the different studies. It is also interesting that it seems like it differs greatly between countries whether country specific factors or global factors are most important for the house price development. According to both Terrones & Otrok (2004) and Jacobsen & Naug (2004) the most important factors determining house price development in Norway are country specific.

6.0. The housing market

The puprose of this chapter is to take a closer look at the housing market in Norway. Some important characteristics of the Norwegian housing policy will be discussed, and the price development in Oslo and Norway will be presented. Further, some relevant statistics will be presented and some empirical measures will be analyzed in order to investigate if the housing prices in Oslo seems inflated[12].

6.1. Norwegian housing policy

The goal of having as many people as possible owning their own homes have been a cornerstone in the Norwegian housing policy ever since the postwar period. The policy measures conducted to reach this goal has proven quite successful, with about 80 percent of Norwegian households owning their own homes. One problem is however that housing is becoming a more and more unequally distributed welfare benefit in Norway. Only 35 percent of low income households own their own homes, in contrast to 96 percent of high income households. This difference is further increasing due to the high price growth in the housing market, as the barriers to enter the housing market for first time buyers and low-income households are getting bigger (NOU 2011:15).

The Norwegian housing policy has gone from being strongly regulated by the state to gradually being liberalized through the 1990s, and since then the housing construction has mainly been controlled by market forces (Sørvoll, 2011). The role of the state today, is to set targets for the housing policy, and to facilitate implementation on the local level. This facilitation includes specifying the legal framework, offer economic aid,

[12] Inflated is here defined as: “Raised or expanded to an abnormal level”.

and contribute with efforts to improve the expertise. The municipalities are responsible for the practical implementation of the housing policy, and the practical implementation might therefore differ between local areas (Husbanken, 2015).

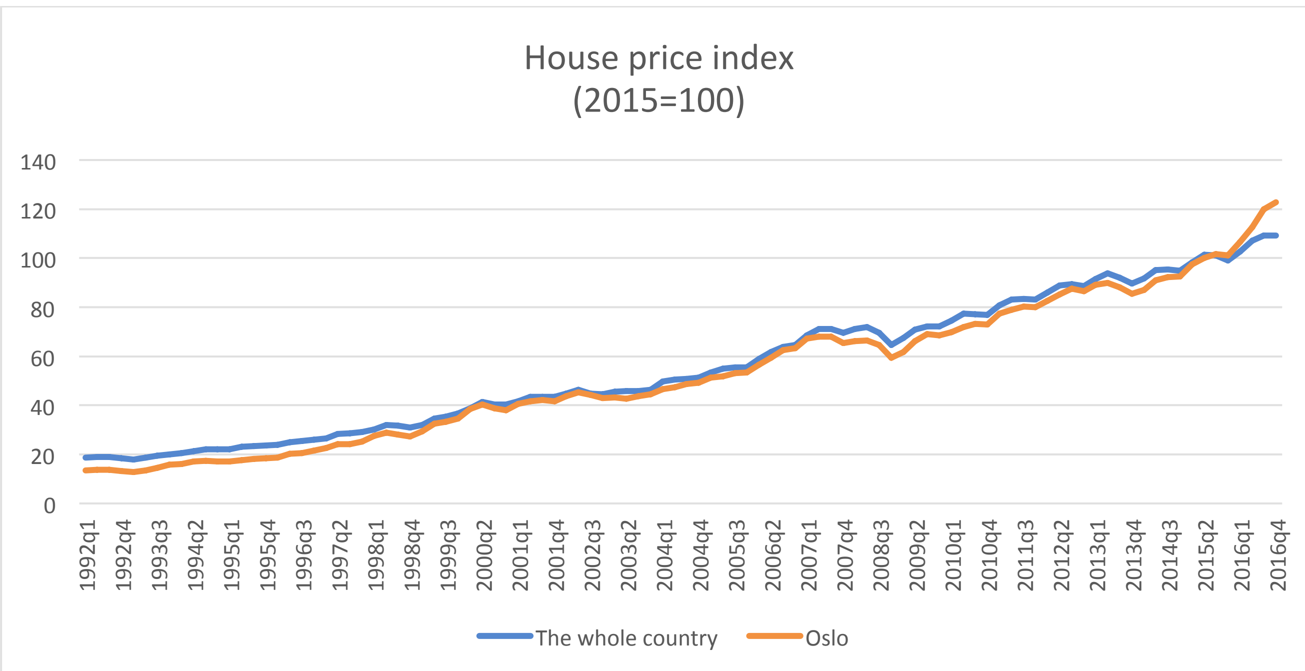
Today's tax system favors housing investment over investment in other assets. Compared to other OECD countries, Norway has a low tax level on housing and property. Further, the municipal tax on real estate is relatively modest. There is also possible to avoid taxation on capital gain from housing sales. The only requirement is that the owner has lived in the dwelling for at least one of the two last years before the sale (Sørvoll, 2011). Some argue that this favorable tax system for housing is one of the reasons for the high price growth in the housing market today. According to Bø (2015) low housing taxation leads to over-investment in housing, at the expense of investment in other assets. Bø further argues that increased housing taxation is the solution not only to increasing housing prices, but also a mean to reduce the high debt level in Norway, as housing investment and the debt level is closely related. Furthermore, Bø sees it as advantageous for economic efficiency through restructuring of investment, and a possible mean to increase the tax income without discouraging labor supply. Taxes is usually thought of as having a decreasing effect on housing prices, but as this reasoning shows, favorable taxes may actually lead to an increasing demand, and thereby a positive effect on the housing prices. According to Bø (2015)'s research, increasing housing taxation to the same level as for other assets will reduce housing prices with about 18 percent.

The Norwegian model, that favors owning rather than renting, puts a huge economic risk on households, as owning requires both high equity and a personal responsibility for repaying debt. However, the risk associated with being a house owner has been a little discussed theme in the housing policy debate. Even though the last 24 years has provided housing investors with a considerable profit, the historical development in housing prices shows that this is not always the case. Housing is a cyclical asset, and we should therefore expect prices to fluctuate. There is no guarantee that house prices will not fall in the future (Sørvoll, 2011). The Norwegian model creates a widespread preference for investing in housing instead of other assets. Not only is it economic beneficial due to tax savings, but it has become a status symbol to own instead of rent housing. As discussed under the bubble chapter, a widespread preference for investing in a specific asset is actually an important amplifier for development of bubbles. In Norway, mortgage-secured loans account for more than 80 percent of bank's lending to households (Jacobsen & Naug, 2004) and the household debt level is much higher than comparable countries (IMF, 2016). A decline in housing prices may therefore have a huge impact on the overall economy in Norway, and many people may end up selling in a bust period due to problems with financing their debt.

6.2. Price development

The housing prices in Norway and Oslo have seen an incredible growth since the bottom in 1992. This can be illustrated with data from SSB's house price index.

Figure 6.1. House price development in Oslo and Norway from 1992 to 2016

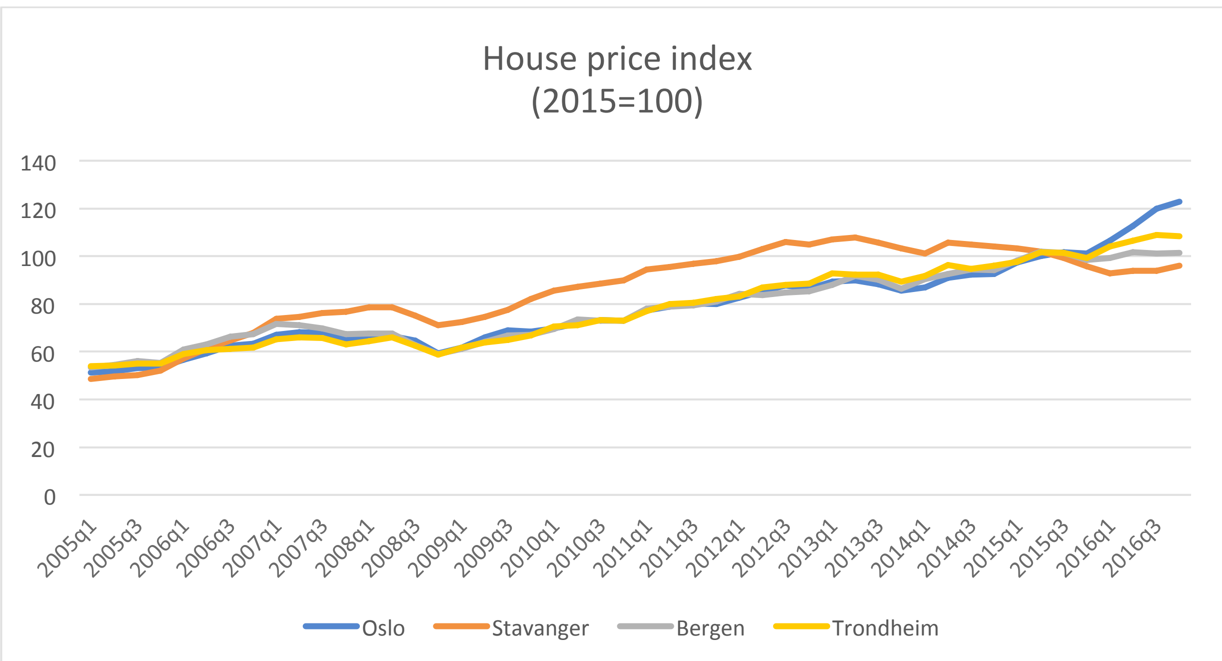


(Source: SSB (2017b))

Figure 6.1. shows a continuous price increase in Oslo and Norway since 1993, only with an exception of a small decline as a result of the financial crisis in 2008. The price index for the whole country has increased from 18.8 to 109.1, and the price index for Oslo has increased from 13.5 to 122.9. The house prices in the country as a whole have therefore increased fivefold, and the house prices in Oslo have increased eightfold during this period. This clearly illustrates that the housing market in Norway is in a boom period. The graph also shows that the house price growth in Oslo has picked up the last two years, while the growth in the country as a whole seem to remain at approximately the same level.

Figure 6.2. below illustrates the house price development in Norway's four biggest cities. The house price index from SSB for Bergen, Stavanger, and Trondheim only goes back to 2005. With such a short data set, it is a bit difficult to see clearly how the price development has been. We can, however, use this graph to look at differences between the four cities. As we can see from the graph, Stavanger has experienced a stronger growth than the three other cities. The price growth in Stavanger picked up after the financial crisis in 2008, and kept on rising until the oil plunge in 2014. As the center of the oil industry in Norway, Stavanger has experienced declining housing prices the last three years. The price growth in Oslo, Bergen and Trondheim have been on approximately the same level. However, this graph also clearly illustrates that the price growth has picked up in Oslo compared to the other big cities the last two years.

Figure 6.2. House price development in Norway's four biggest cities 2005 to 2016

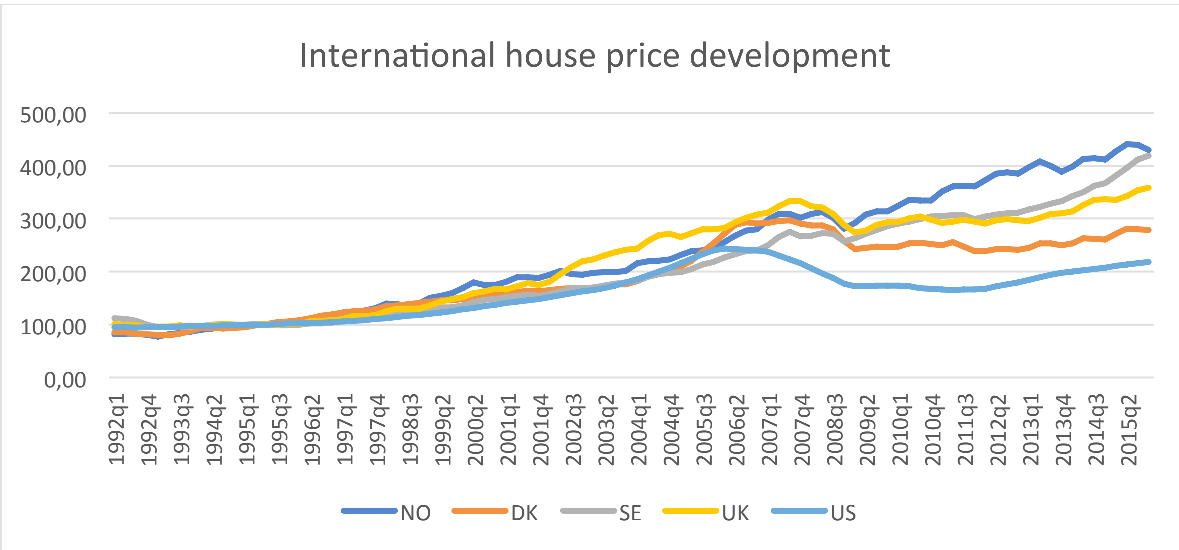


(Source: SSB (2017b))

It is also interesting to investigate how the price development have been in Norway compared to comparable international countries. Figure 6.3. below illustrates the price development in Norway, Denmark, Sweden, the United Kingdom and the United States. As we can see from the graph, the price growth in all these countries were on approximately the same level before the financial crisis. The interesting part, is the development after

2008. The growth in housing prices in the US, the UK and Denmark are still lower than before the crisis, while the price growth is much higher in both Norway and Sweden. The growth level has been higher in Norway than in Sweden, but it seems like the price growth in Sweden has picked up in the last couple of years, now being on approximately the same level as in Norway. The question is whether this price growth is driven by underlying fundamental factors, or if this price growth is a bubble in the housing market.

Figure 6.3. International house price development 1992 to 2015



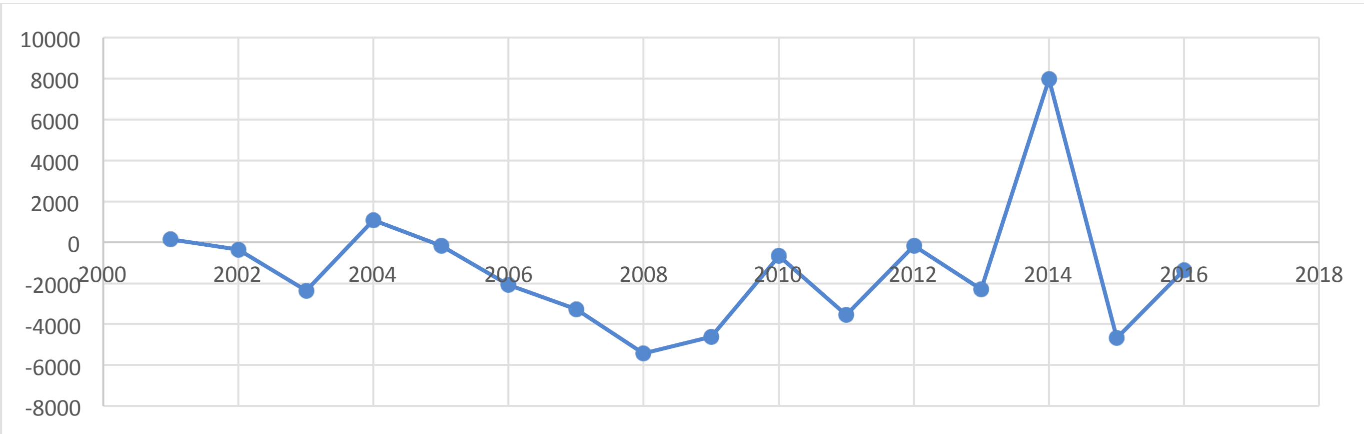
(Source: BIS (2016))

6.3. Relevant statistics

6.3.1. Population growth and housing supply

The population growth in Oslo has been high the last 24 years, and the population has grown from 473 454 to 658 390 people (SSB, 2017a). This has driven the housing demand in Oslo. The question is whether the housing supply has kept up with this increased demand.

Figure 6.4. Gap between new households and completed dwellings

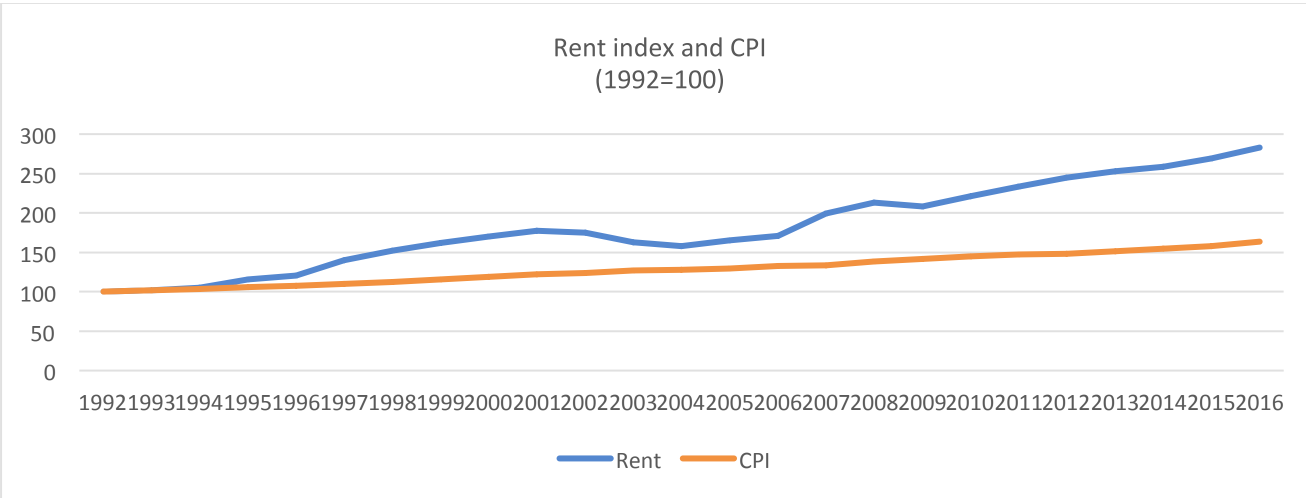


(Source: SSB (2016a), SSB (2017a), SSB (2017e), Appendix 1)

Figure 6.4. shows the gap between new households in Oslo and completed dwellings. This graph illustrates that in the period between 2000 and 2016 there has been a supply deficit in almost the entire period, the exceptions being in 2004 and 2014. The jump in 2014 can be greatly explained as a result of negative net migration this year, with one possible explanation being the oil plunge the same year. On average, there has been a deficit of housing supply of 1362 dwellings during this period. This illustrates that there is a gap between supply and demand in the housing market in Oslo, and this gap is an important explanatory factor for the price growth we see in the housing market today.

As housing services may be consumed either by owning or renting, the development in rent prices may also provide us with valuable information about the supply of housing in Oslo. The data on Oslo rents are collected from two price indices. Oust (2013) have constructed a hedonic rent index from 1970 to 2008. From 2009 to 2016 I have used a hedonic rent index constructed by Opinion Perduco for Boligbygg Oslo KF (2015). The method and data used are very similar, and the rent indices are adjusted for quality such as location, type of dwelling and size (Krakstad & Oust, 2015). The price index from Boligbygg Oslo KF (2015) is published quarterly, so in order to get the data on a yearly basis I have taken the average of four quarters. Thereafter, I have calculated the yearly change and used this change to calculate a measure of Oust rent from 2009 to 2016, see Appendix 2.

Figure 6.5. Rent index and CPI 1992 to 2016

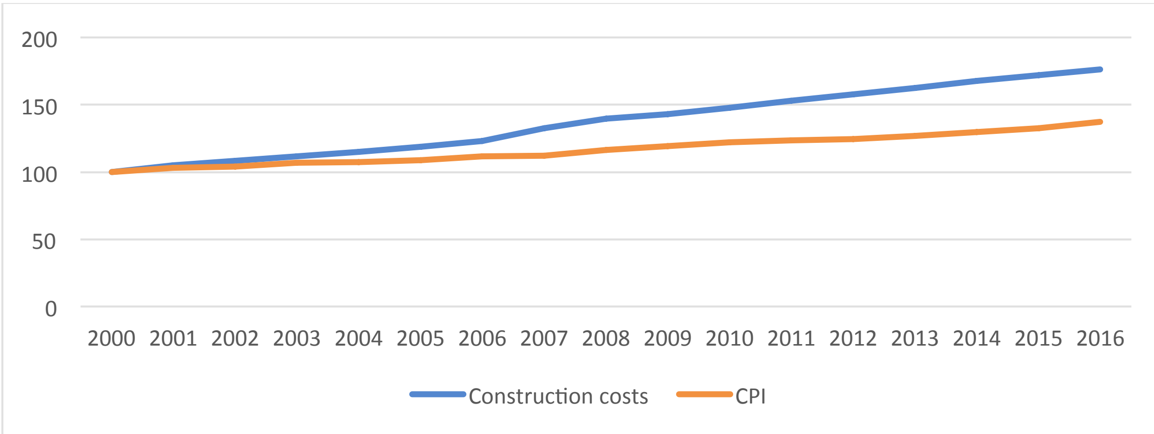


(Source: Oust (2013), Boligbygg KF Oslo (2015), SSB (2017d), Appendix 2)

Figure 6.5. shows the development in the rent index and CPI from 1992 to 2016. As the graph shows, rent prices have increased more than the relative price level in the economy, and this growth has increased further since 2010. One explanation for this price development might be that the housing supply is lower than the housing demand, driving the rent prices up. The high price growth in the housing market makes it more difficult for first time buyers to enter the housing market, and this can be one reason for the increased demand in the rental market.

The high population growth in Oslo since 1993 can be explained by a positive net migration, both due to an urbanization trend and due to migration from outside of Norway. Further, the life expectancy is increased, where we see less stillborn and live longer lives (SSB, 2017a). According to SSB's population projections the population growth in urban areas are expected to continue, and Oslo is expected to surpass 700 000 people over the next ten years (Tønnessen,Leknes, & Syse, 2016). We can therefore expect the housing demand to continue to increase in the years to come. It is therefore important to investigate further why the housing supply has not met the increased demand in Oslo.

Figure 6.6. Development in Construction costs and CPI



(Source: SSB (2017d), SSB (2017f))

As derived under sub-chapter 3.2.2. the most important factor driving residential investment is construction costs. Figure 6.6 illustrates the development in construction costs, mainly labor and material costs, compared to the development in the relative price development in other goods and services (CPI). In order to make the two measures comparable, the consumer price index from SSB is here presented with the basis year sat to 2000 instead of 2015. As we can see from the graph, construction costs have increased gradually from 2000, with a steeper growth from 2010. The reason for the steeper growth from 2010 can be attributed to the introduction of the TEK 10 regulations. These regulations apply to new housing construction, and has requirements regarding technical necessities, land utilization, design, and installations, to mention some (Dibk, 2016). Increasing construction costs have a negative effect on housing construction in Oslo, as it gets relatively less profitable to invest in residential property.

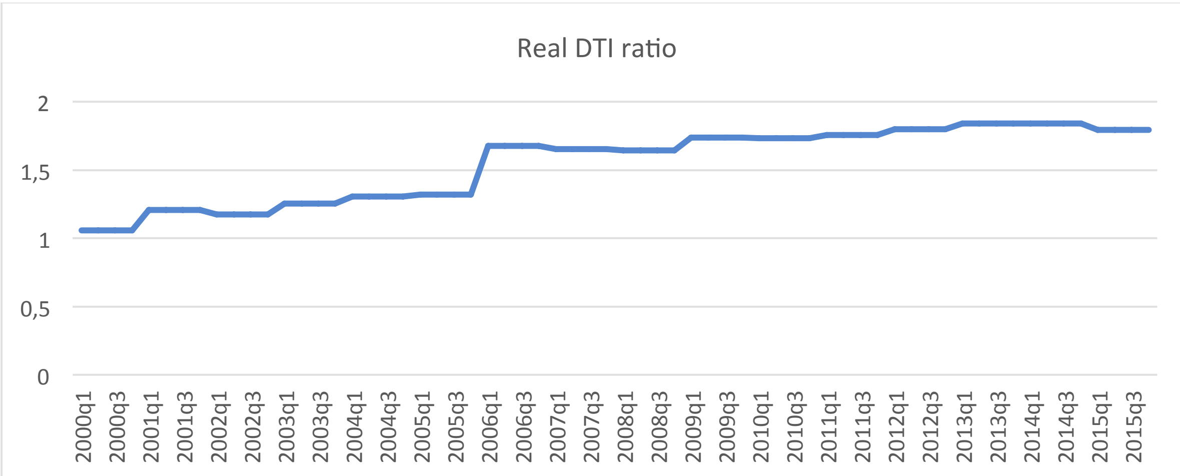
Another important factor worth investigating is land costs. As explained under sub-chapter 3.2.2. we can expect an increase in demand to lead to a permanent increase in land costs in urban areas where the supply of land is limited. There is no public available data on land costs in Oslo, and despite my persistent effort to gather historical data on land prices in Oslo, I did not succeed. It is, however, reasonable to assume that land prices will be greatly affected by the availability of land, and land is a scarce resource in Oslo. With the sea in the west, and the "Markalov" (forest law) that forbid construction above a certain border in the north, this certainly limits the construction possibilities. Further, the approved building height is regulated in Oslo. The regulatory authorities are working to keep Oslo's character and history, and do not want the city to have a skyline of skyscrapers. In most areas of Oslo, buildings higher than 12 floors are therefore not approved (Plan- og bygningsetaten, 2015). This thereby restricts the possibility to build in the height. In addition, TEK 10 do not only affect construction costs, but also the availability of land through regulations on land utilization. Higher construction costs and inelastic land supply can explain why the housing supply in Oslo has not kept up with the housing demand.

6.3.2. Household debt

The credit market and housing market are closely related. Dwellings are most often highly debt-financed and collateralized by the property itself. The development in a country's credit market should therefore be seen in close relation to the development in a country's housing market. The household debt in Oslo have on average increased by 8 percent yearly from 2000 to 2015 (SSB, 2015b). This is interesting as the average growth in housing prices has been 6 percent in the same period (NCB, 2016). Accumulated, the household debt has increased by 188 percent, and the average household debt per person were 864 800 NOK in 2015 (SSB, 2015b)

A high household debt level further increases the instability in case of a decline in housing prices through a potential spillover-effect between the housing market and the credit market (Anundsen, 2013). The debt to income (DTI) ratio indicates household's ability to repay their debt. Investigating the development in the DTI ratio can therefore provide some valuable information about the possible consequences of a decline in the housing market.

Figure 6.7. Development in real DTI ratio 2000 to 2015



(Source: SSB (2017d), SSB (2015b), Appendix 3)

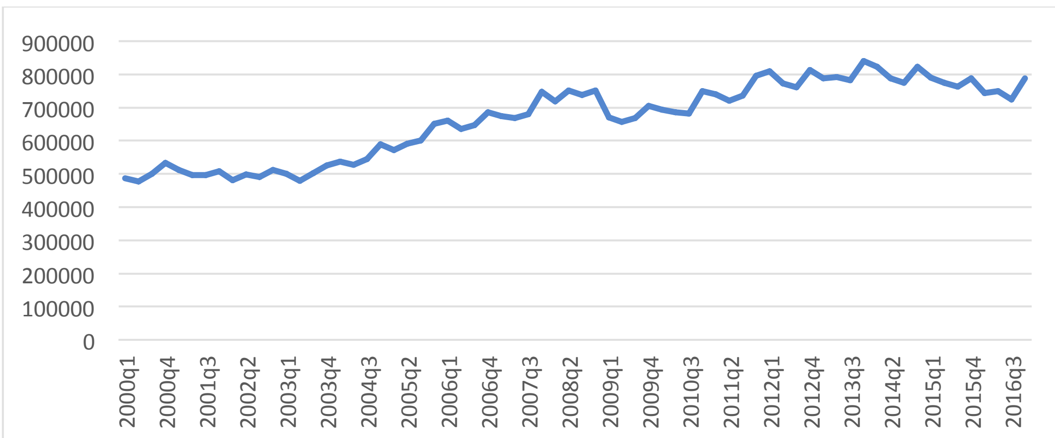
Figure 6.7. illustrates development in the real DTI ratio in Oslo from 2000 to 2015. As we can see from the graph, the DTI ratio has increased gradually since 2000. Due to low interest rates, households are able to repay debt levels high above their income levels, and the 2015-level indicates that households on average hold debt at a level 1,80 times their income.

Increasing borrowing costs would make it more difficult for many households to repay their debt. Due to prudential regulation, the risk of widespread financial instability in case of household credit defaults is small in Norway. However, increasing borrowing costs would affect household consumption, and could therefore result in significant macroeconomic effects (OECD, 2016). There are no indications pointing towards interest rate increases in the year to come. In case of changes in the economic stability or declining housing prices, I do however find this debt level alarmingly high.

Increasing housing prices and low interest rates are the two most important factors driving this development in housing debt. The key ratio is the lowest in the history of Norwegian economy at only 0.5 percent. Increasing the key ratio could work as a stabilizer both for the growth in housing prices and the debt level. However, NCB is in a dilemma. The falling oil prices forces Norway to become more competitive in other industries in order to counteract a possible recession in the Norwegian economy. The key ratio therefore needs to stay low. As a mean to dampen the growth in household debt and housing prices, the government has put in place stricter lending policies functioning from the 1th of January 2017. The main idea behind these lending policies is that it shall be more difficult to build up a high debt level. There has also been implemented some stricter policies that only apply for Oslo. The government are especially trying to reduce the speculation in the market, and the new policies states that when buying a secondary residence in Oslo, 40 percent of the purchase shall be financed with equity (the normal equity claim is 15 percent). How effective these new lending policies are will be interesting to see. One negative implication of these lending policies is that they will mostly affect low-income households, making it even more difficult for these households to enter the housing market.

6.3.3. The macroeconomic situation

Figure 6.8. Development in real GDP



(Source: SSB (2017g))

The economic situation in Norway has been good the last two decades, and the macroeconomic situation has been characterized with income growth and low unemployment. Figure 6.8. illustrates the real GDP development in Norway between 2000 and 2016. Except for a small decline as a result of the financial crisis in 2008 the real GDP has increased continuously until the oil plunge in 2014. The economic consequences of the oil plunge have been smaller than first expected. With "Statens Pensjonsfond Utland" (the Norwegian oil fund) working as an economic buffer and the low interest rate supporting the activity level, the Norwegian economy has avoided a recession. The last two quarters of 2016 even shows signs of a positive development in the real GDP. However, the future economic outlooks are uncertain, both in Norway and in the rest of the world. The oil plunge showed how dependent the Norwegian economy is on the oil industry, and the development in the oil industry will therefore be important for the economic development. A potential recession in the Norwegian economy will greatly affect the development in the housing prices and could potentially result in a steep fall in housing prices.

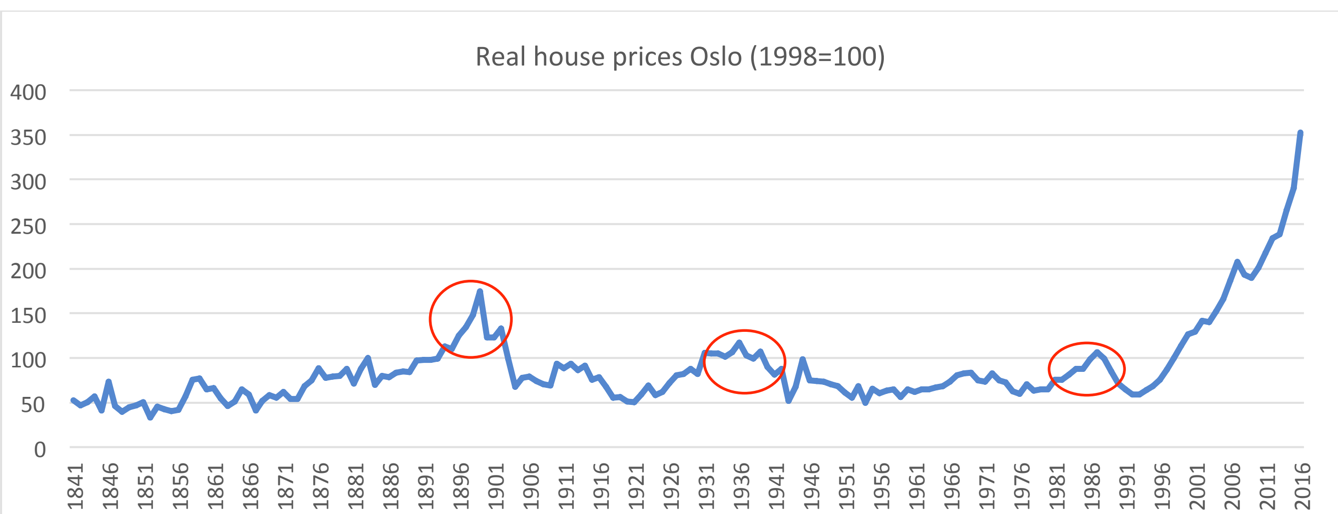
6.4. Does house prices in Oslo seem inflated?

The high house price growth in Oslo makes it natural to question whether there is a bubble in the housing market. In this sub-chapter a preliminary investigation of this question will be conducted by studying if the housing prices in Oslo seem inflated. In order to investigate this question, the three empirical measures: real house price development, the price-to-construction costs ratio and the price-to-rent ratio will be analyzed below.

Real house price development

The development in real house prices is a measure of how the development in housing prices have been compared to the development in other goods and services. A substantial increase in real house prices is an indicator of a housing bubble, as this means that the house price growth is abnormal compared to the relative price development in the economy (Grytten, 2009a).

Figure 6.9. Real house price development in Oslo 1841-2016



(Source: NCB (2016), Appendix 4)

Figure 6.9. above illustrates the house price development when accounting for the relative price development in other goods and services, with the basis year sat to 1998. The house price index is taken from NCB and is the longest data set it is possible to retrieve for house price development in Oslo.

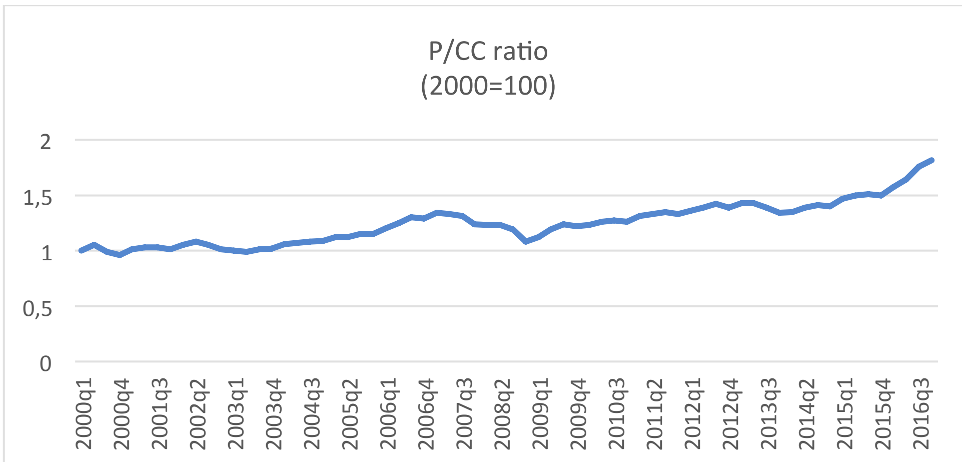
As the graph show, house prices have been relatively stable between 1841 and 1993, except for three boom-and-bust episodes highlighted with a red circle. The first housing bubble depict in the graph has later been named the "Kristiania crisis" and took place around 1899. A strong urbanization, income growth, and an expansive monetary- and credit policy drove the demand for housing in Oslo. This increased demand led to an excessive building boom. When the housing demand later declined, the bubble burst and real house prices dropped 23 percent. The second bubble depict in the graph followed as a result of the Post-War depression during the 1920's. This bubble was not a result of increasing housing prices, but a result of a strong deflation due to a tight monetary policy with a goal that the Norwegian krone should appreciate 100 percent. The third housing bubble depict in the graph is the biggest housing bubble seen in Norway. This bubble developed as a result of the liberalization of the credit market during the 1980's. Increased access to credit and an expansive monetary policy drove the demand for housing. When the bubble burst in 1992, real house prices dropped more than 40 percent (Grytten, 2009b).

From 1993 we see something that look like an abnormal price growth. The only exception from continuous growth is a small decline as a result of the financial crisis in 2008. The price growth in housing prices have been considerably bigger than the growth in other goods and services, and the price growth we have seen since 1993 is not like any price growth seen in the housing market earlier. Between 2000 and 2015 real house prices have increased with as much as 129 percent. This can definitely be characterized as a substantial increase, and we can conclude that the real price growth indicates that house prices in Oslo are inflated. If this price increase turns out to be a bubble, this will be the fourth housing bubble we have seen in Norway, and possibly also the biggest.

Price-to-construction costs ratio

Another measure that can be investigated for indications of a housing bubble is the price-to-construction costs ratio. This coefficient is equivalent to Tobin's q, described under sub chapter 3.2.2, and describes the relationship between market prices and construction costs of housing. In the long-term we expect housing prices and construction costs to converge. If the P/CC coefficient shows a strong increasing trend over time, this is an indication of a bubble in the market (Grytten, 2009a).

Figure 6.10 Price-to-construction costs ratio



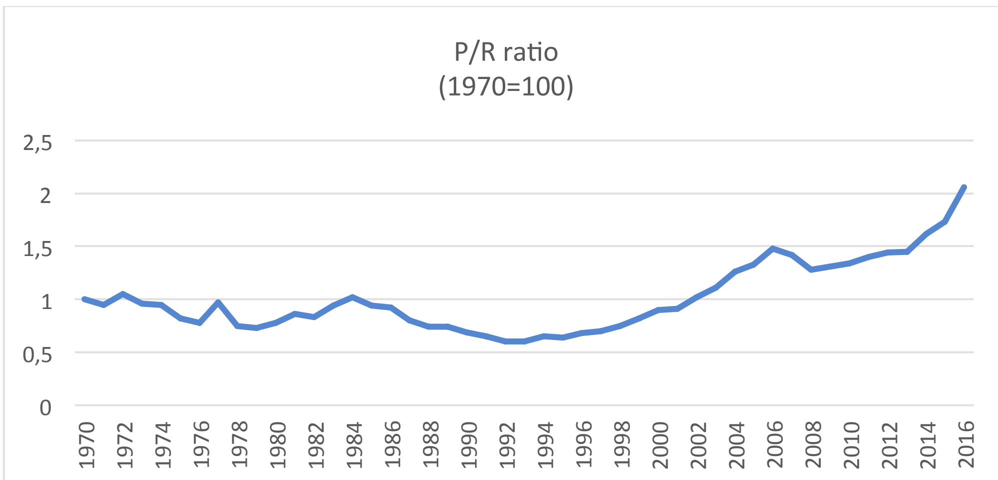
(Source: SSB (2017b), SSB (2017f), Appendix 5)

Figure 6.10 illustrates the quarterly development in the price-to-construction costs ratio between 2000 and 2016. The construction cost index only goes back to 2000, so studying the historical development before 2000 is therefore not possible. However, we can investigate how the development have been in recent years. As we can see from the graph, the P/CC ratio shows an increasing trend. Between 2000 and 2016 the P/CC ratio has increased from 1 to 1.8. Considering that this increase has happened over a period of only 15 years, I would argue that this is a substantial increase, and this indicates that housing prices in Oslo are inflated. There are, however, some limitations to this measure, as discussed in sub-chapter 3.2.2. The main problem with studying the development in the P/CC ratio for Oslo is that this measure does not take the costs of land into consideration. Inelastic supply of housing in the long-term due to limited availability of land, could possibly explain why we see an increasing trend in the P/CC ratio.

Price-to-rent ratio

The price-to-rent ratio can also be investigated for indications of a bubble in the housing market. This measure describes the relationship between market prices and rents. Rents can be assumed to be sat to cover both cost of ownership and profit for the house owner. Rents can therefore be seen as a measure of what a dwelling is actually worth (fundamental value). If the P/R ratio increases substantially over a longer period of time, this means that it gets relatively more profitable to rent than to own housing. This is an indication of inflated housing prices as a result of a bubble in the market (Grytten, 2009a).

Figure 6.11. Price-to-rent ratio



(Source: NCB (2016), Oust (2013), Boligbygg KF Oslo (2015), Appendix 6)

Figure 6.11. illustrates the development in the price-to-rent ratio between 1970 and 2016. Except for a decline as a result of the housing bubble crash in 1992 and the financial crisis in 2008, we see a continuous increase in the P/R ratio. The graph further shows that the growth in the P/R ratio has picked up in recent years, and between 2000 and 2016 we see a growth in the P/R ratio of 129 percent. This can definitely be characterized as a substantial increase, and according to the P/R ratio house prices in Oslo seem inflated.

Summing up, the housing prices in Oslo seem inflated when studying the historical development in real house prices, the price-to-construction costs ratio and the price-to-rent ratio. The intuition is that if these measures exceeds their long-term average, this is an indication of a housing bubble (Grytten, 2009). As discussed under sub-chapter 4.2.1. these ratios are, however, incomplete, as they do not measure whether housing prices are high due to a bubble, or due to development in fundamental factors. As described under sub chapter 4.1. a bubble can be defined as a situation where an asset has a higher value than what can be justified by its fundamental value. As we now have seen, there has been a continuous price growth in the housing market in Oslo. The question is whether this price increase can be explained by changes in underlying fundamental factors, or whether this price increase is a speculative bubble building up. I will investigate this question by developing a house price model for Oslo. By conducting a regression analysis on fundamental factors, the goal is to explain the development of housing prices in Oslo. If the analysis turns out to explain little of the development in house prices, this is an indication of a potential housing bubble in the market.

7.0. Econometric method

The purpose of this chapter is to explain the theory behind the econometric method that will be used in this thesis. Economic theory concerning time series analysis will be presented, and possible problem areas will be discussed. Further, the concept of error correction models will be explained. The theory presented here is mainly based on Wooldridge (2012) and Hobdari (2014).

7.1. Time Series Econometrics

In this thesis, I am going to investigate how the house prices in Oslo have developed over time, and how much of this development can be explained by changes in underlying fundamental factors. Time series econometrics is a good tool for such investigations, as it accounts for the time dimension, and makes it possible to differ between short-term and long-term relationships between macroeconomic variables (Wooldridge, 2012). Under follows an example of a simple static model:

$$(7.1)\ Houseprice_t = \beta_0 + \beta_1 Factor_{t1} + \beta_2 Factor_{t2} + \cdots + \beta_k Factor_{tk} + u_t,$$

Where: u_t = error term and $t = time\ period$

This model can be calculated with the use of OLS, and will provide unbiased coefficient estimates given that the three first Gauss-Markov assumptions are satisfied. For the OLS estimators to be BLUE (Best Linear Unbiased Estimator) the fourth and fifth assumptions also need to be satisfied.

TS.1. Linear in parameters: The stochastic process $\{x_{t1}, x_{t2}, \dots, x_{tk},\ Y_{ti} : t = 1,2, \dots, n\}$ follows the linear model Y_t=$\beta_0 + \beta_1 x_{t1} + \cdots + \beta_k x_{tk} + u_t$, where $\{u_t: t = 1,2, \dots, n\}$ is the sequence of errors of disturbances.

TS.2. No perfect Collinearity: No perfect linear combination between the explanatory variables.

TS.3. Zero conditional mean: The error u has an expected value of zero for all the explanatory variables in all time periods. $E(u_t \mid X) = 0, t = 1,2, \dots, n$.

TS.4. Homoscedasticity: The error term shall have constant variance in all time periods. $Var(u_t \mid X) = Var(u_t) = \sigma^2, t = 1,2 \dots, n$.

TS.5. No autocorrelation: No correlation between the error term in different time periods. $Corr(u_t, u_s \mid X) = 0 \; for \; all \; t \neq S$.

If these assumptions are not satisfied, the model will provide biased coefficient estimates that will be either above or below the true population value. For the regression results to be fully efficient, all of the assumptions above should therefore be satisfied (Wooldridge, 2012).

In order to use the usual OLS standard error, T statistics and F statistics, a final assumption need to be added:

TS.6. Normality: The errors u_t are independent of X and are independently and identically distributed (i.i.d) as normal (0,σ^2).

A model that satisfies this assumption makes it a lot easier to interpret the regression results (Wooldridge, 2012).

7.2. Times series and seasonality

A common problem in time series analysis is when the data is quarterly or monthly data that contains seasonality. A simple method to deal with seasonality in regression models is to include dummy variables to control for seasonality. This is typically done by including three dummy variables in the model, for example S1 S2 and S3. Let's say that they represent spring season, summer season and fall season. Then winter season will be our reference point, which means that we compare the others seasons to the winter season. In this way the model will account for seasonality when the data is not seasonally adjusted (Wooldridge, 2012).

7.3. Stationarity

According to Wooldridge (2012), a variable is defined as stationary if its probability distribution does not change over time. This means that if we take a collection of random variables and move them h time periods, the joint probability distribution must remain unchanged. Formally this can be defined as: The stochastic process $\{x_t: t = 1,2, \dots\}$ is stationary for all time periods if the complete probability distribution $(x_{t1}, x_{t2}, \dots, x_{tm})$ is the same as for $(x_{t+h1}, x_{t+h2}, \dots, x_{t+hm})$ for all h ≥ 1. For a time-series to be considered stationary, the following assumptions need to be met:

1. $E(x_t) = u \; for \; all \; t$
2. $Var(x_t) = \sigma^2 \; for \; all \; t$
3. $Cov(x_t, x_{t+h}) = p \; for \; all \; t \; and \; all \; h \neq 0.$

A stochastic process is therefore said to be stationary if its mean and variance are constant over time, and the value of the covariance between the two different time periods depend only on the distance between the time periods[13]. A stationary time series will tend to be mean reverting, meaning that it will not drift too far away from its mean value (Hobdari, 2014).

If a time series is not stationary according to the definition above, it is called a non-stationary time series and will have a time-varying mean, a time-varying variance, or both (Hobdari, 2014). Many macroeconomic variables have probability distributions that change over time, as they often follow a time trend or are dependent on the development in other macroeconomic variables. Non-stationary variables may also have a unit root, meaning that the variance is time dependent and often increases over time. Non-stationary means that two or more variables that at first glance look independent, may increase or decrease together over time. One example here is the relationship between the two variables housing investment and house prices. Both housing investment and house prices follow an upward sloping trend, and ignoring this time trend can lead us to falsely conclude that changes in one of these variables is actually caused by the other. In the literature, this is defined as a spurious or "nonsense" regression. Trending variables do not necessarily violate the Gauss-Markov assumptions. Spurious regressions are, however, often characterized with an artificially high R^2, and it is therefore important to recognize time trend in order to draw causal inferences when using time series data (Woodridge, 2012).

To solve the problem with non-stationary variables, we can try to take the first difference of the variables. This means that we take the value of the variable today minus the value in the previous period, and get the variable in a differenced form:

[13] In the literature, we differ between strong and weakly stationarity. The stationarity defined above is weakly stationarity, also referred to as covariance stationary. In most practical situations, this type of stationary suffices, and it is also sufficient for the regression analysis conducted in this thesis.

$$\Delta Factor_t = Factor_t - Factor_{t-1}$$

The idea is that the time trend or unit root will be eliminated as this trend do not differ between time periods. If $Factor_t$ becomes stationary after taking the first difference, we say that $Factor_t$ is integrated of order 1, denoted as $I(1)$. If a time series is stationary from the beginning, it is said to be integrated of order zero, denoted $I(0)$. If a time series has to be differenced d times to make it stationary, that time series is said to be integrated of order d, denoted as $I(d)$. Most variables are generally $I(1)$, meaning that only the first difference is necessary to make the variable stationary (Hobdari, 2014). Differencing do, however, create another problem, as information about long-run dynamics will disappear. In this thesis, I am interested in both the short-and long-run dynamics of house prices in Oslo. One way to fix this problem is to use an error correction model. The error correction model will be further explained in sub-section 7.5 below.

7.3.1. Testing for stationarity

The most commonly used tests for stationarity in the literature is the Dickey-Fuller (DF) test or alternatively the Augmented Dickey-Fuller (ADF) test. This test is a unit root test where stationarity is tested by investigating if a time series follows a unit root process or not (Woodridge, 2012). I will explain how this test works by using this simple dynamic Autoregressive model, AD(1):

$$(7.2)\ y_t = \alpha + \rho y_{t-1} + u_t,\ t = 1,2, \ldots,$$

Where: $u_t\ are\ i.i.d. with$ a mean equal to zero and a constant variance

The value y_t is here explained as a result of the last period value, the correlation coefficient ρ, the constant α, and the error term u_t. As $u_t \sim N(0,1)$, it is assumed to be "white noise" and therefore stationary. For the process in equation (7.2) to be stationary α should be equal to zero and $\rho < 0$. This implies that y_t will converge towards its mean, $E(y_t)$, when exposed to a random shock. If ρ on the other hand is equal to 1, the process in equation (7.2) has a unit root and will follow a random walk[14] which is a nonstationary process. If $\alpha = 0\ and\ \rho = 1$, $\{y_t\}$ follows a random walk, and if $\alpha \neq 0\ and\ \rho = 1$, $\{y_t\}$ is a random walk with drift, meaning that E(y_t) is a linear function of t. In order to test if equation (7.2) has a unit root, we can now set up the following hypothesis test:

[14] The name random walk comes from the fact that y at time t is obtained by starting at the previous value y_{t-1} and adding a zero-mean variable that is independent of y_{t-1}. Stock prices are often assumed to be a random walk, where today's stock price is equal to yesterday's stock price plus a random shock.

$$H_0: \rho = 1$$

$$H_1: \rho < 1$$

It is common to leave α unspecified in the hypothesis test and I am therefore doing the same here. The alternative to the test above would be to test $H_1: \rho > 1$, but this is usually not done because it implies that y_t is explosive. If we find that the alternative hypothesis is true, we say that the process in equation (7.2) is a stable AR(1) process, which means that is it weakly dependent or asymptotically correlated[15] (Woodridge, 2012).

A common approach to carry out the DF test is to subtract y_{t-1} on both sides of equation (7.2):

$$(7.3)\ \Delta y_t = y_t - y_{t-1} = \rho y_{t-1} - y_{t-1} + u_t = (\rho - 1) y_{t-1} + u_t$$

In this way, the test statistic for the DF test becomes a normal t-test specified as:

$$DF = \frac{\hat{\rho} - 1}{se(\hat{\rho})}$$

Where $se(\hat{\rho})$ is the normal OLS standard deviation of $\hat{\rho}$. This t statistic do, however, not have an approximate standard normal distribution even in large sample sizes, and the normal critical values for t statistics do therefore not apply. When performing the DF test, we therefore need to use the Dickey-Fuller distribution. If our test statistic, DF, is bigger than the critical value given by the Dickey-fuller distribution, we discard the null hypothesis and conclude that our process is stationary (Woodridge, 2012).

As specified above, the DF test assumes that the error term is only "white noise". This means that there should be no autocorrelation in the error term for the DF test to provide unbiased results. This assumption will seldom hold for time series, and an alternative to the DF test when we expect the error term to be autocorrelated, is to use the Augmented Dickey-Fuller test. The intuition behind the ADF test is that we modify equation (7.2) by incorporating a constant term α, a time trend ηt and lagged variables Δy_{t-1} in our simple dynamic model in order to remove the autocorrelation in the error term. Under the ADF test we estimate the following model:

$$(7.4)\ \Delta y_t = \alpha + \eta t + (1 - p) y_{t-1} + \sum_{i=1}^{n} \lambda_i \Delta y_{t-1} + u_t$$

[15] A time series is characterized as weakly dependent if the correlation between x_t and x_{t+h} goes to zero "sufficiently quickly" as $h \to \infty$. Further, a time series is characterized as asymptotically correlated if $corr(x_t, x_{t+h}) \to 0\ as\ h \to \infty$.

Number of lagged variables (n) that should be estimated can be found by looking at the t statistic of each of the lagged variables and see if it is significant or not. Another alternative is to use Akaike's information criterium (AIC) or Swartz's Bayesian information criterium (SBIC). Both of these information criterium's are incorporated in the big statistics programs such as STATA, SPSS and Eviews, and they are therefore easy to apply in practice. Whether or not a constant and time trend should be estimated depends on the data. If the data contains a clear intercept and/or time trend they should be included in the estimation. The easiest way to investigate this is to graph the time series in advance. The ADF test is carried out just like the DF test, but the critical values we should use are dependent on which factors we incorporate in our model (Wooldridge, 2012).

The DF and the ADF test are the most popularly used tests for stationarity. The reason for this is probably because they are intuitive and easy to apply. These tests have, however, also received some critique. One problem with these tests is that they have low power, that is, they tend to accept the null hypothesis of unit root more frequently than is warranted. Another issue is that the tests are sensitive to the way they are conducted. The true level of significance differs between the three different models: (1) Pure random walk, (2) A random walk with drift and (3) A random walk with drift and trend. This is a problem if the true model for example is (1) but we estimate (2). It is therefore important to keep these limitations in mind when conducting the tests (Hobdari, 2014).

7.4. Autocorrelation

Autocorrelation, also called serial correlation, can be described as a situation where the disturbance term (u) relating to any observation is related to or influenced by the disturbance term relating to any other terms. Autocorrelation is a common problem in time series regression. There are several reasons for the emergence of autocorrelation in time series, three common reasons being: a delayed response to changes in macroeconomic variables, a misspecification of the regression model, or manipulation of the data used (like transforming monthly data to quarterly or yearly data). Autocorrelation violates TS.5. of the Gauss-Markov theorem. The OLS estimates will still be unbiased, but not BLUE (Best Linear Unbiased Estimator). The reason for this is that autocorrelation makes the variance of OLS estimators biased. The consequence is that the usual OLS standard errors and test statistics are not generally reliable. It is therefore important to control for autocorrelation between the error terms (Hobdari, 2014). We can control for autocorrelation with the use of robust standard errors. Applying robust standard errors is easy to do in practice, but one problem with the use of robust standard errors is that we often find the coefficient to be insignificant or less significant than we do when we use the usual OLS standard errors (Wooldridge, 2012). Before using robust standard errors, it is therefore important to test for autocorrelation.

7.4.1. Testing for autocorrelation

Autocorrelation can be tested for with both graphical and statistical tests. Starting with a visual examination of the OLS residuals can give valuable insight about the likely presence of autocorrelation[16]. Thereafter, a statistical test should be chosen for a further analysis. The most popularly used test among practitioners is the Durbin-Watson d statistic. This test is, however, not applicable for models containing lagged values of the dependent variable, as this violates one of the assumptions underlying the test (Hobdari,2014). An alternative to the Durbin-Watson test that can be used for models with lagged variables, is the Box and Pierce (1970) Q-test. The Box-Pierce test tests the null hypothesis of no autocorrelation against the alternative hypothesis of autocorrelation, given the following test statistic:

$$Q(r)_{BP} = n\sum_{k=1}^{m} r_k^2 \sim \chi^2 \text{ with m degrees of freedom}$$

Where n equals number of observations, m is the maximum lag length and r_k is the value of the estimated autocorrelation coefficient in period k. The problem with the Box-Pierce test is that it yields biased results for small samples. Ljung and Box (1979) has developed an alternative Q-test that also works for small samples, like the sample that I will investigate in this thesis. The Ljung-Box test is given by the following test statistic:

$$Q(r)_{LB} = n(n+2)\sum_{k=1}^{m}\frac{r_k^2}{n-k}. \text{ When } n \to \infty\ Q(r)LB = Q(r)BP.$$ [17]

The difficulty with the Ljung-Box test in practice is that the maximum number of lags need to be specified, and a too high or low number of lags may result in a biased result from the test. There has so far not emerged a uniform rule for the decision on number of lags, though Burns (2002) has found that it is important to hold the number of lags relatively small compared with the sample size. According to Burns (2002), number of lags should not be much more than 5 percent of the length of the sample, and certainly not more than 15 percent.

[16] See appendix 7 for further explanation and illustration.
[17] The interested reader is referred to Box & Pierce (1970) and Ljung & Box (1979) for a thorough derivation.

7.5. Cointegration and spurious regressions

The problems depicted above concerning nonstationary time series and autocorrelation can be solved by changing the model (7.1) presented above to include the first difference of the variables and robust standard errors. The model would then look like this:

$$(7.5)\ \Delta Houseprice_t = \beta_0 + \beta_1 \Delta Factor_{t1} + \beta_2 \Delta Factor_{t2} + \cdots + \beta_k \Delta Factor_{tk} + u_t$$

Where: u_t = error term, $\Delta = the\ first\ difference$, and $t = time\ period$

Given that the variables are actually $I(1)$, this model will produce meaningful results, and this will be a good model for investigating short-run dynamics in the housing market. However, in this thesis I want to investigate both short-run and long-run dynamics, and I therefore want to add variables in my model that are not on a differenced form. The use of an error correction model makes it possible to investigate both short-term and long-term relationships, given that the variables of analysis are cointegrated (Wooldridge, 2012).

Cointegration can be explained with the following example. Let us assume that house prices and housing investment are both $I(1)$. According to the theory, the regression of housing investment on house prices should yield a "nonsense" result. There is, however, a possibility that the two series of analysis share the same common trend so that the regression of one variable on the other, will not generate a spurious regression. If we further assume that we now test the error term (u) of the regression between house prices and housing investment and find that it is stationary, $I(0)$, we have a case where the linear combination of the two series cancels out the stochastic trends, and we get a meaningful result. When this is the case, we say that the two variables are cointegrated and we call the regression a cointegration regression. Here, I presented an example with only two variables, but the concept of cointegration can be extended to a regression model with k regressors (Hobdari,2014).

In order to test for cointegration, the Engle and Granger (1979) two step approach can be used. The first step in the Engle-Granger approach is to estimate the cointegration regression by OLS and obtaining the residuals, u. The second step is to test u for a unit root by applying the Dickey-Fuller or Augmented Dickey-Fuller test as described above. The only difference here is that the residuals are themselves estimates, and the regular DF and ADF critical values are therefore not appropriate. When conducting the Engle-Granger test or the

Augmented Engle-Granger test we therefore need to use the critical values calculated by Engle and Granger[18] (Hobdari, 2014). For a thorough derivation of the Engle-Granger approach, see Engle and Granger (1979).

7.6. Error correction model

If our variables are cointegrated as described above, we can use an error correction model (ECM). An error correction model makes it possible to analyze both the short-run dynamics and long-run dynamics between the dependent variable and the explanatory variable(s). In addition, this model provides information about the rate of adjustment to the long-term equilibrium relationship (Black, J., Nigar H., & Gareth, Myles, 2012). An error correction model does also solve the problem with non-stationary variables and spurious regressions.

In order to introduce the concept of error correction models, I will here present a simple autoregressive distributed lag (ADL) model based on (Wooldridge 2012, p.651-652).

$$(7.6)\ Houseprice_t = \alpha_0 + \alpha_1 Houseprice_{t-1} + \gamma_0 Factor_t + \gamma_1 Factor_{t-1} + u_t$$

Where: $u_t\ are\ i.i.d.with$ a mean equal to zero and a constant variance

If we now assume that $Houseprice_t$ and $Factor_t$, a vector of macroeconomic variables, are $I(1)$ processes and cointegrated with parameter β, this makes it possible to make more complex dynamic models. Let us first solve the problem of non-stationarity by putting the variables in first differences:

$$(7.7)\ \Delta Houseprice_t = \alpha_0 + \alpha_1 \Delta Houseprice_{t-1} + \gamma_0 \Delta Factor_t + \gamma_1 \Delta Factor_{t-1} + u_t$$

We now want to transform model (7.7) into an error correction model in order to get information about the error correction coefficient. In the first step, we estimate an error term from a separate model with OLS:

$$(7.8)\ Houseprice_t = \hat{\beta} Factor_t + s_t, \text{ where } s_t \text{ is the error term.}$$

Engle and Granger (1987) find that including the estimate ($\hat{s}_t$) directly in the error correction model gives unbiased and efficient results, where $\hat{s}_t = Houseprice_t - \hat{\beta} Factor_t$. As explained under the sub section about cointegration, this error term becomes a $I(0)$ process as $Houseprice_t$ and $Factor_t$ are cointegrated.

In the second step, we add the lagged variable of $\hat{s}_t$ in equation (7.7):

[18] These critical values can be found in Davidson and MacKinnon (1993, Table 20.2.).

$$(7.9)\ \Delta Houseprice_t = \alpha_0 + \alpha_1 \Delta Houseprice_{t-1} + \gamma_0 \Delta Factor_t + \gamma_1 \Delta Factor_{t-1} + \delta \hat{s}_{t-1} + u_t$$

This is the Engle-Granger two-step procedure. Equation (7.9) is an example of an error correction model and δ is what we call the error correction coefficient, which explains the speed the dependent variable, $Houseprice$, uses to get back to a long-term equilibrium after a temporarily shock in the explanatory variable, $Factor$ (Wooldridge, 2012).

The Engle-Grange two-step procedure is commonly used among practitioners as it is easy to use and provides unbiased and efficient estimates. One problem with this procedure is however that we lose information about the long-run dynamics, as we calculate the long-term equilibrium in a separate model as part of step one in the procedure. If we instead calculate the error correction model in one step, this opens up the possibility to estimate and interpret the long-run dynamics of the explanatory variables of analysis. The one-step procedure will be used in this dissertation, and this procedure will therefore be further elaborated on below.

When we estimate the error correction model in one step, this mean that we instead of calculating the lagged variable of $\hat{s}_t$ in a separate model, include this variable directly in the error correction model. Given that the variables are cointegrated, this model will provide unbiased and efficient estimates. Using the same model as presented in equation (7.6), a one-step error correction model can be specified as follows:

$$(7.10)\ \ \alpha_0 + \alpha_1 \Delta Houseprice_{t-1} + \gamma_0 \Delta Factor_t + \gamma_1 \Delta Factor_{t-1} + \delta(Houseprice_{t-1} - \hat{\beta} Factor_{t-1}) + u_t$$

Equation (7.10) cannot be calculated directly in statistic programs such as STATA and Eviews , as we do not have information about β. Estimation of a one-step error correction model therefore requires some calculations. In the following, a one-step procedure for estimation of error correction models will be presented. This procedure is based on the work of Banerjee, Dolado, Galbraith & Hendry (2003)[19].

For simplicity $Houseprice$ (the dependent variable) will now be referred to as y and $Factor$ (the vector of explanatory variables) will be referred to as x. The ADL model presented in (7.6) can now be described as:

(7.11) $y_t = \alpha_0 + \alpha_1 y_{t-1} + \gamma_0 x_t + \gamma_1 x_{t-1} + u_t$, Where: $u_t\ is\ i.i.d.with$ a mean equal to zero and a constant variance

The main problem with estimating the parameters in (7.11) is that house prices and other macroeconomic variables often are non-stationary. This model could therefore provide spurious results. This can be solved by

[19] See Leighton (1997) for a more academic presentation of this procedure.

taking the first difference of y and x, as both are $I(1)$ processes. We subtract y_{t-1} on both sides of (7.11) and then add and subtract $\gamma_0 x_{t-1}$ on the right-hand side to get:

$$(7.12)\quad \Delta y_t = \alpha_0 + \lambda y_{t-1} + \gamma_0 \Delta x_t + (\gamma_0 + \gamma_1) x_{t-1} + \mu_t, \text{ Where: } \lambda = (\alpha_1 - 1)$$

Equation (7.12) can now re-parameterizes by defining $\beta_1 = \frac{\gamma_0 + \gamma_1}{\lambda}$ and $\beta_0 = \frac{\alpha_0}{\lambda}$, providing the following equation:

$$(7.13)\ \Delta y_t = \gamma_0 \Delta x_t - \lambda (y_{t-1} - \beta_0 - \beta_1 x_{t-1}) + u_t, \text{ where: } \beta_1 = \frac{\gamma_0 + \gamma_1}{\lambda} \text{ and } \beta_0 = \frac{\alpha_0}{\lambda}$$

This equation is equivalent to equation (7.9) described above, but can be interpreted in a new and interesting way. β_0 and β_1 are long-run parameters, while γ_0 and λ are short-run parameters. The γ_0 parameter describes the short-term effect on y of one unit change in x. The λ parameter is the error correction parameter, and estimates the adjustment speed back to equilibrium. This parameter will always lie between 0 and 1, where a value of 0 means that there is no long-term relationship between x and y. The β_1 parameter describes the long-run effect on y of a unit change in x. This long-run effect will be distributed over future periods in accordance with the adjustment speed, λ.

If we now multiply out the bracket in equation (7.13) we get a linear model that we can estimate with OLS:

$$(7.14)\ \Delta y_t = \gamma_0 \Delta x_t - \lambda y_{t-1} + \lambda \beta_0 + \lambda \beta_1 x_{t-1} + u_t$$

For simplicity I rewrite this equation and get:

$$(7.15)\ a + b \Delta x_t + c y_{t-1} + d x_{t-1} + u_t, \text{ where: } a = \lambda \beta_0, b = \gamma_0, c = -\lambda \; and \; d = \lambda \beta_1$$

By running a regression of Δy_t on $\Delta x_t, y_{t-1}$, and x_{t-1}, this gives us estimates of $a, b, c \; and \; d$. As $\lambda = -c$, it follows that $\beta_0 = \frac{-a}{c}$ and $\beta_1 = \frac{-d}{c}$. Here β_0 and β_1 are the long-run parameters and c is the error correction parameter.

To test if there is co-integration between the dependent variable and the explanatory variable(s) in the one-step error correction model described above, one can check that c is negative and significant in a normal t-test (Banerjee, Dolado, Galbraith & Hendry, 2003, p.155). Estimating the error correction model in one-step has therefore advantages both when it comes to theoretical analysis and statistical analysis.

8.0. An empirical model of house prices

In this chapter I will present the empirical house price model created to analyze the development in housing prices in Oslo. This house price model has been developed based on the theoretical foundation and previous house price models presented above.

8.1. Presentation of variables

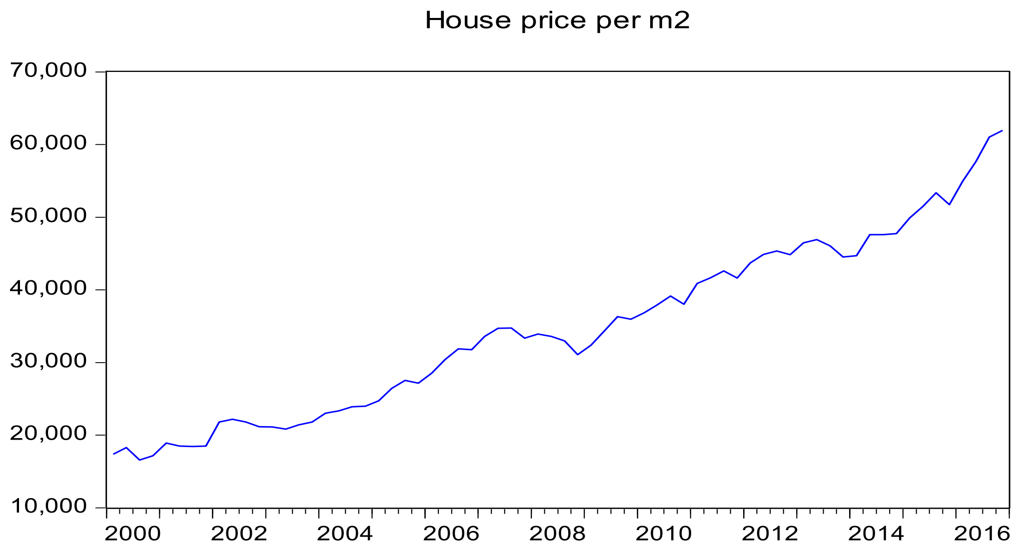
When choosing variables for econometric testing, it is important to bear in mind that even though two variables are correlated doesn't necessarily mean that they have a causal relationship. Including variables that do not have a causal relationship with housing prices will make the model unreliable and provide spurious results. Variables should therefore be chosen based on well-founded economic theory (Wooldridge, 2012).

8.1.1. The dependent variable

I have chosen to use the average square meter price per freeholder as the dependent variable in the model. This variable is stated quarterly and gathered from SSB's Statbank in table 03637 and table 05963. The numbers are stated nominally, and are not seasonally adjusted. The data sources are mainly housing sales through Finn.no and data produced by Eiendom Norge for Finn.no.

From the first quarter of 2000 to the fourth quarter of 2001 housing prices were calculated using the utility floor space. From the first quarter of 2002, prices are stated per square meter useful floor space. The housing prices before and after the fourth quarter of 2001 are therefore not directly comparable. I have solved this problem by including a dummy variable called UFS for the period where useful floor space is used in the regression. UFS = 1 from the first quarter of 2002 and equal to zero in the quarters before. In that way the model account for the different measurement methods. To avoid the effect of potential big outliers in the data, and to make it possible to interpret the estimated coefficients as elasticities, I will do a logarithmic transformation of the data. Further, I will transform the data into real values. This will be discussed further in sub-chapter 8.2. Below follows a graphical illustration of the house price data used in my analysis:

Figure 8.1. House prices per square meter, 2000q1-2016q4



(Source: SSB)

8.1.2. The explanatory variables

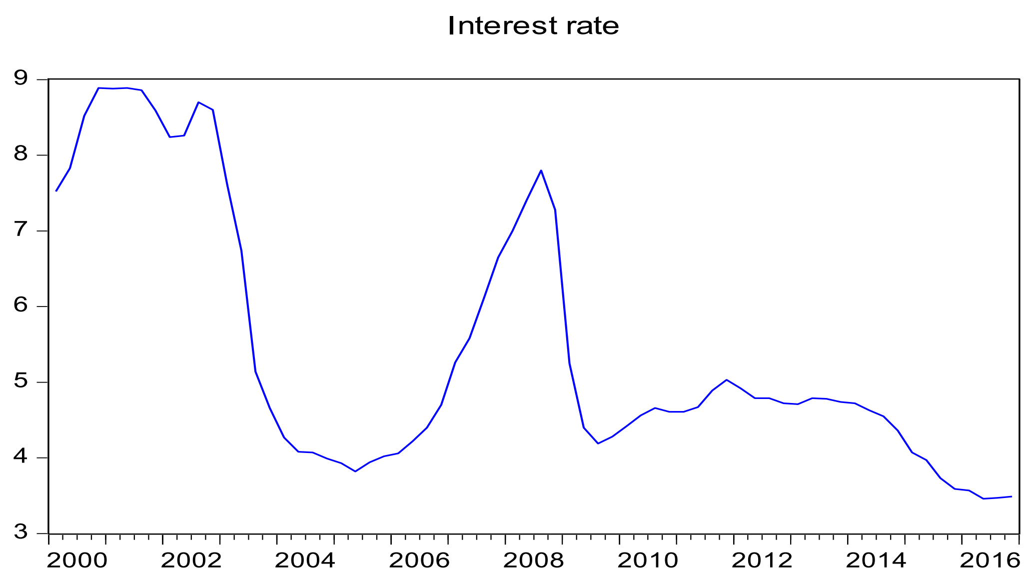
The explanatory variables in the model were chosen based on economic theory and the definition of fundamental explanatory factors as "Economic factors affecting the supply and demand dynamics in the housing market". Further, the previous house price models presented above were studied as a mean to provide valuable empirical information. Below follows a short description of each variable.

Average interest rate banks

In the literature, interest rate is specified as one of the most important fundamental factors driving house prices. I have therefore chosen to incorporate this factor in my model. I have chosen to use a national average of banks' interest rate on outstanding loans in my analysis. This data is gathered from SSB's Statbank in table 07200. The numbers are stated nominally, and are not seasonally adjusted. The numbers are stated on a quarterly basis in percent, and I choose to keep the numbers on this form in my model. The data sources for the statistics are mainly The Norwegian Public Service Pension Fund and data collected through the accounting and supervisory reporting system (ORBOF). These numbers are not specific for Oslo, but this is not a problem as banks' interest rate do not differ between regional areas.

The reason why I have chosen this data is that this is the interest rate consumers meet when they apply for mortgage loans. One could possibly argue that a longer interest rate such as a ten year bond rate would be a more fitting choice as the payback period traditionally is long for mortgage loans. The average interest rate sat by banks is, however, a decisive factor for whether consumers can afford to buy housing or not, and I therefore find this data the most appropriate to use in the model. In Norway it is most common with floating interest rate, and the proportion of fixed interest rate is small. According to Finanstilsynet (2016) only around 4 percent of the total loan amount in Norway have fixed interest rate, and five years is the most common rate period for these loans. This further support that a shorter interest rate is better for explaining the development in housing prices in Oslo. Below follows a graphical illustration of the interest rate data used in my analysis:

Figure 8.2 Average interest rate banks, 2000q1-2016q4



(Source: SSB)

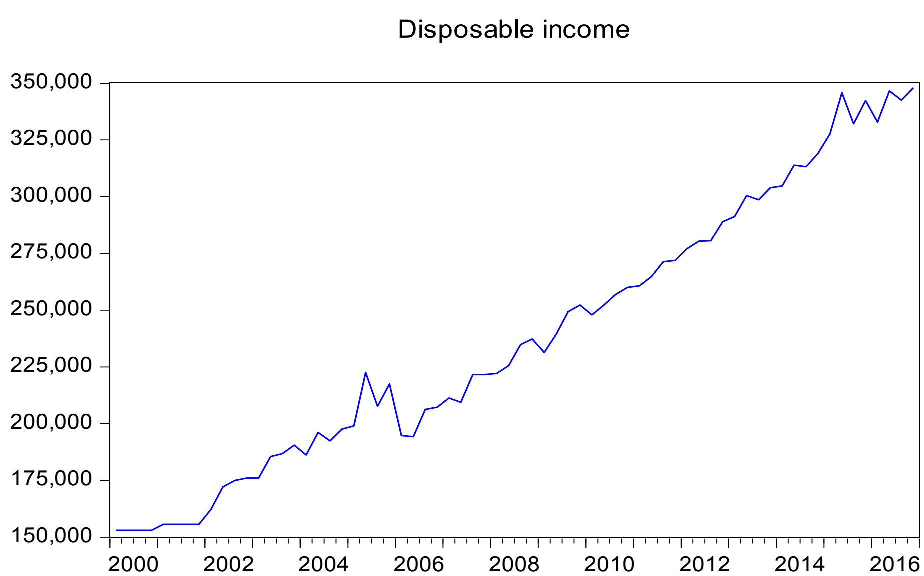
During the period of analysis, Norway has had a marginal tax rate on capital income and capital expenditure of 28 percent until 2014, and 27 percent after this. Before applying this variable in the model, I will deduct this tax in order to get a more exact measure of the interest costs. Further, I will transform the data into real values. This will be discussed further in sub-chapter 8.2.

Disposable income

Income is, according to the literature and previous studies, one of the most important fundamental factors driving house prices. I have therefore chosen to incorporate this factor in my model. I have chosen to use household disposable income in my analysis. This data is taken from the national accounts and are therefore not specific for Oslo. In the literature I find that it is most common to use aggregated numbers for income, and I have therefore decided to do the same in this model.

The data is gathered from SSB's Statbank in table 10799 and 11020. The numbers are stated nominally, and are not seasonally adjusted. The data before 2002 is stated on a yearly basis, and I chose to transform these variables into quarterly data by dividing the yearly average by four. The data will not vary within the same year, but it will still vary between years. This will therefore not violate the Gauss-Markov assumption concerning no perfect collinearity. However, transforming yearly data into quarterly data will create a problem, as the lower variation in the income variable will cause the explanatory power to be small. I still find it important to include this variable, as income is an important fundamental factor for house price development in the literature. Not including this variable in the model might actually lead to spurious results. Further, it will only be year 2000 and 2001 where this is an issue. Below follows a graphical illustration of the income data used in my analysis:

Figure 8.5. Disposable income, 2000q1-2016q4



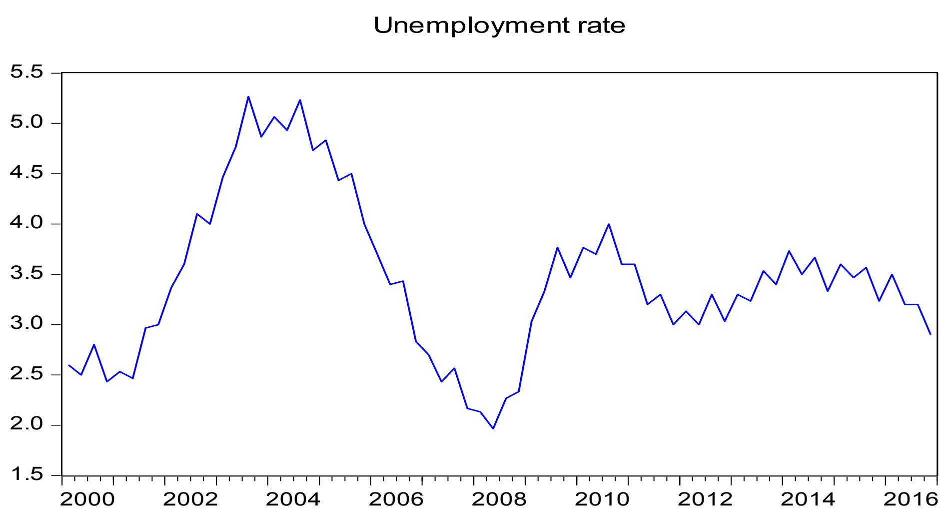
(Source: SSB)

As we can see from the graph above, it has been a high growth in average gross income over the period of analysis. Especially we see a high growth after 2006. In order to avoid the effect of potential big outliers in the data, I will do a logarithmic transformation of the data. Further, I will transform the data into real values. This will be discussed further in sub-chapter 8.2.

Unemployment rate

According to earlier studies, unemployment is an important fundamental factor driving house prices. I have therefore decided to incorporate this variable in the model. I use data for registered unemployed people in Oslo between 15 and 74 years in my analysis. This data is gathered from SSB's Statbank in table 10540, and are based on data from NAV's administration system (the unemployment office in Norway). The numbers are stated as a percentage of the labor force and I decided to keep them on this form in the model. As the data is stated on a monthly basis, I take the average of three and three months in order to convert the data into quarterly numbers. Below follows a graphical illustration of the unemployment rate used in my analysis:

Figure 8.4. Unemployment rate, 2000q1-2016q4



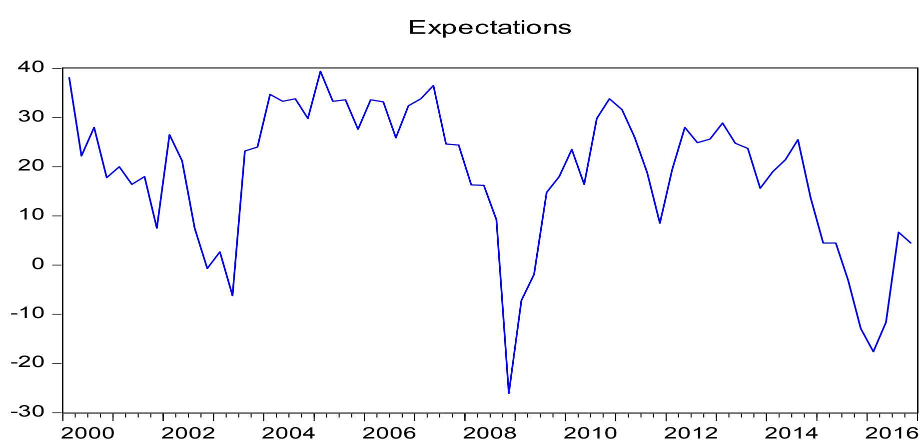
(Source: SSB)

As we can see from the graph above, the unemployment rate has been low in the period of analysis and has been lying on a stable and low level the last five years. One limitation with this data is that it only considers people who are actively seeking income-earning work, and might therefore underestimate the true unemployment level. I do however believe that this data is representative for the unemployment level, and I have no reason to believe that this underestimation will affect the results of my analysis in an important way.

Household expectations

Households' expectations concerning their own financial situation and the Norwegian economy is an important factor affecting the demand for housing. I have therefore chosen to incorporate this factor in my model. TNS Gallup constructs a consumer confidence indicator based on households' expectations concerning their own financial situation and the Norwegian economy, that I have chosen to use in my analysis. The consumer confidence indicator is based on surveys conducted by Kantar TNS in cooperation with Finans Norge. Surveys are conducted each quarter, and the same five questions are asked to a randomly selected group of one thousand representatives. The answers from the surveys are transformed into number values, and from these values the consumer confidence indicator is constructed. As I expect households' expectations to differ between regions, I decided to use regional data for consumer confidence in my analysis[20]. It was not possible to gather data only for Oslo, but the data used is for the Oslo/Akershus region. This is stated on a quarterly basis and are not seasonally adjusted. Below follows a graphical illustration of the consumer confidence indicator for Oslo/Akershus:

Figure 8.3. Consumer confidence indicator, 2000q1-2016q4



(Source: «Forventningsbarometeret 2.kvartal 2017, gjennomført av Finans Norge og Kantar TNS»)

[20] Thank you Ann Håkonsen from Finans Norge for providing me with regional data and helping with all my questions

As we can see from this graph above, expectation about own financial situation and the Norwegian economy have been good in the period of analysis expect for a plunge as a result of the financial crisis in 2008 and the oil crisis in 2014. Further, this graph shows that expectations is a quite volatile variable.

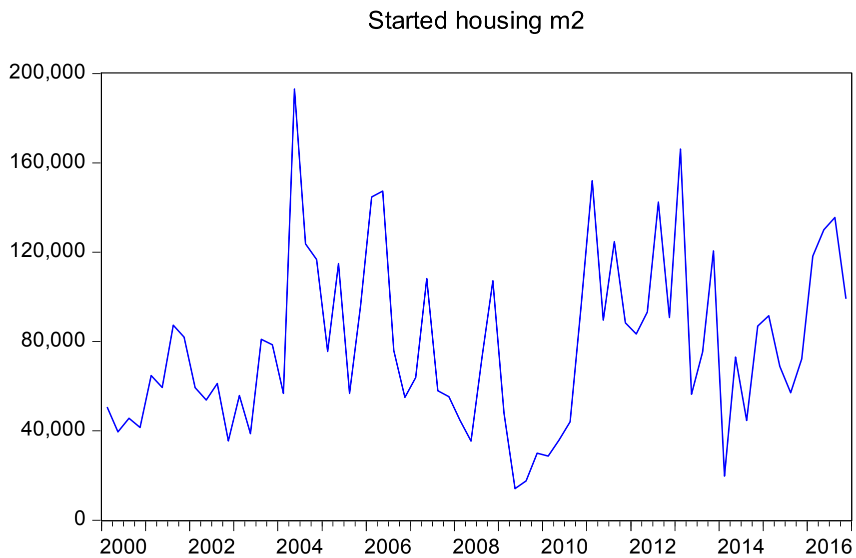
A potential problem with this variable is that it naturally can be highly correlated with the development in the unemployment rate and the interest rate. This can create problems concerning multicollinearity as these factors will also be included in my model. This problem can be solved by running a regression of the consumer confidence indicator with interest rate and unemployment rate as explanatory variables. The estimated error term from this regression (the difference between estimated and actual value) is an unbiased estimate of household expectations not affected by interest or unemployment. This method is taken from Jacobsen & Naug (2004) as it is outside the scope of this thesis to construct a new model for household expectations. My estimation and modelling of household expectations will be presented in sub-chapter 8.3.

Housing construction

According to theory and previous studies, residential investment is one of the most important fundamental factors driving house prices. As it is not possible to retrieve data on residential investment specific for Oslo, I have decided to include housing construction as a measure of residential investment in my model. I have decided to use building work started in square meters in my analysis. This data is gathered from SSB's Statbank in Table 05889. The numbers are stated in square meters and are based on Matrikkelen, which is a computer register containing information about ground properties and addresses in Norway. The data is presented at the end of each quarter and is not seasonally adjusted.

The reason why I decided to include a variable for started housing construction and not finished housing construction in the model, is that I find this a more updated indicator of the development in residential investment. It takes time to build new housing, and using finished housing construction as a measure of residential investment could be misleading about how the development have been during one exact period. I find that it is most common in the literature to use housing construction in NOK, and not square meters. I had to choose square meters as it is no other data to choose from for Oslo. However, I do not believe that this will have any important effects on the end result of my analysis. Below follows a graphical illustration of the construction data used in my analysis:

Figure 8.7. Housing construction m2 Oslo, 2000q1-2016q4



(Source: SSB)

As we can see from the graph above, housing construction is a quite volatile variable and differs considerably from quarter to quarter. It is also interesting to see that this graph shows a downturn in housing construction both during the financial crisis in 2007 and during the oil plunge in 2014. This indicates that residential investment actually follows the economic cycle as predicted by economic theory.

8.1.3. Dummy variables

I have also decided to include five dummy variables in the model. UFS has already been presented in sub-chapter 8.1.1. This is a dummy variable included to control for the change in measurement method of housing prices from the first quarter of 2002. The second dummy variable I have decided to include in my model is Financial Crisis. This variable is equal to 1 between the third quarter of 2007 and second quarter of 2009, while 0 in all other periods. This variable is included to control for the effects of the financial crisis. Further, I include three variables to adjust for seasonality: S1, S2, and S3. They represent the spring, summer and fall season. As it follows, winter is then the reference point. S1 is equal to 1 for January, February and March, while 0 in all other periods. S2 is equal to 1 for April, May and June, while 0 in all other periods. S3 is equal to 1 for July, August and September, while 0 in all other periods.

8.2. Real vs. nominal values?

That a time series is real means that we have adjusted it for inflation, where inflation can be described as the relative price development in other goods and services. The Norwegian indicator for inflation is the consumer price index (CPI) produces by SSB. Data for CPI can be found in SSB's Statbank in Table 03013. Nominal values can be transformed to real values with the following formula:

$$(8.1)\ Real\ value_t = \frac{Nominal\ value_t * 100}{CPI_t}$$

The main argument for transforming nominal values to real values is that real values describes the actual development, and not the development driven by inflation. As we saw from the presentation of previous house price models, there is no consensuses of whether nominal or real values should be used to analyze housing prices. Personally I find it more suitable to use real values when studying the housing market, as this makes it easier to get a clear picture of what the actual development has been. In my analysis I will therefore transform house prices, average gross income and the interest rate into real values. I transform house prices and average gross income with the use of equation (8.1) described above. As the interest rate is stated in percentage, this transformation has to be done a little differently. I calculate the real interest rate by subtracting the inflation measured in percentage from nominal interest rate measured in percentage. The inflation formula can be specified as follows:

$$(8.2)\ \text{Inflation (\%)} = \left(\frac{CPI_{t+1} - CPI_t}{CPI_t}\right) * 100$$

Further, real interest rate can be specified with the following formula:

$$(8.3)\ Real\ interest\ rate_t = quarterly\ nominal\ interest_t - quarterly\ inflation_t$$

8.3. Modeling household expectations

This thesis has no objective to develop a new model of household expectations, and I will therefore follow Jacobsen & Naug (2004)'s procedure to model a variable for expectations to use in my analysis. Jacobsen and Naug uses a one-step error correction model, like the one presented in sub-chapter 7.6, to explain the consumer confidence indicator with development in the interest rate and unemployment rate. The error term constructed from this model is thereafter put in a self-composed formula: $EXPEC = (E - F) + 100(E - F)^3$, where: E is the indicator of household expectations concerning their own financial situation and the

Norwegian economy (measured as rate, total over two quarters) and F is the value of E that may be explained by development in the interest rate and unemployment. The result of this formula is the variable they use in their house price model. I find an error correction model to be appropriate for modeling household expectations, as this model makes it possible to eliminate the effects of unemployment and interest rate on expectations, while still accounting for short- and long-run effects. I decided not to use Jacobsen and Naug's specified model for transformation of expectations presented above, as I find no support for such a transformation in the literature. The estimated error term from the estimation of expectations will therefore be used directly in my model.

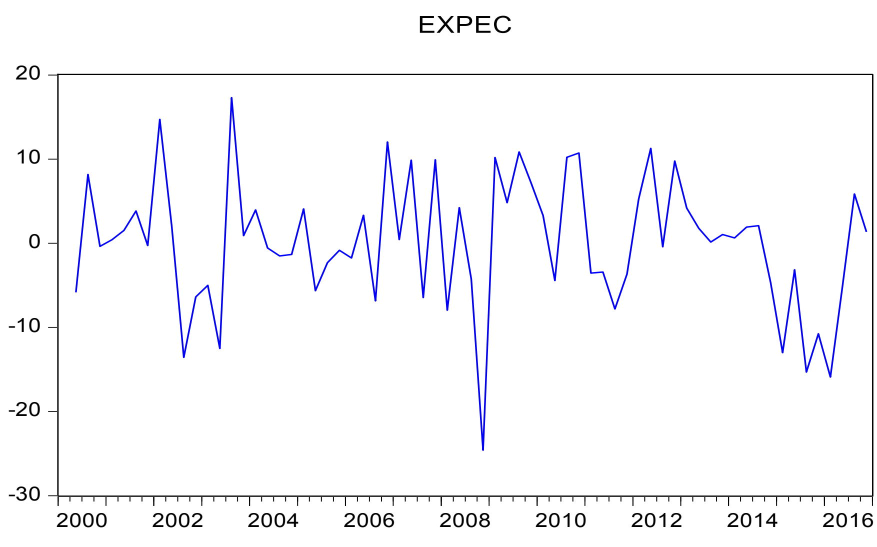
The error correction model I estimate have the following specification:

$$(8.4)\ \Delta Expec_t = \alpha_0 + \gamma_1 \Delta Interest\ rate_t + \gamma_2 \Delta Unemployment_t + \gamma_2 Expec_{t-1} + \gamma_3 Interest\ rate_{t-1} + \gamma_4 Unemployment_{t-1} + \delta_1 S1 + \delta_2 S2 + \delta_3 S3 + u_t$$

Where: t = time period, Δ= the first difference and u_t= the error term.

A table with regression results from model (8.4) can be found in Appendix 8. The estimated error term $(\widehat{u_t})$ is the expectation indicator that will be used on my model. This variable is an indicator of expectations about own economy and the Norwegian economy, not affected by interest rate or unemployment. Below follows an illustration of the constructed expectations indicator:

Figure 8.8. Constructed expectations indicator



(Source: «Forventningsbarometeret 2.kvartal 2017, gjennomført av Finans Norge og Kantar TNS» and own calculations)

8.4. Variables not included in the model

In addition to the ones included in the model, several other explanatory factors could have an effect on the development in housing prices. Rent, construction costs and land costs could all be regarded as important fundamental factors driving the development in housing prices. However, due to lack of regional available data on these variables they have not been included in the model.

Other variables that have been excluded are variables describing demographic conditions, such as population growth and net-migration. These are factors expecting to affect house price development in the long-run. These variables showed no significant effect in my regression analysis, and I therefore decided to omit them from the model. My hypothesis is that these variables showed no significant effect due to the short period of analysis. Demographic conditions changes gradually, and we should therefore not expect these changes to have a significant effect over a time period of 16 years. With a longer data set I would, however, expect these variables to have an significant effect on the price development in the housing market.

One difficulty with studying economic factors driving house price development is that many of these factors naturally are highly correlated. Appendix 9 shows a correlation matrix describing all factors considered to be included in the analysis. As we can see from this matrix, income is highly correlated with both debt and stock market prices. The fact that debt and income are highly correlated comes as no surprise, as how much debt households are able to take on depends on their opportunity to repay installments and interest rates. We should also expect income and share prices to be highly correlated as both follows the development in the economy. The problem with highly correlated variables is that this contradicts assumption 2 of the Gauss-Markov assumption, no perfect collinearity. Collinearity can give rise to spurious results, as it increases the standard errors, and may result in variables that should be significant may be found not to be significant. In regression analysis it is therefore important not to include too many variables that are highly correlated in the analysis. I therefore decided to omit both debt and stock market prices from my analysis. Income is emphasized as one of the most important factors for development in housing prices, both in the literature and empirically, and I therefore find this more important to include than debt and stock market prices.

8.5. Testing for stationarity

The Augmented Dicker-fuller test derived under sub-chapter 7.3.1. will now be used to test the variables included in the model for stationarity and integration order. To find number of lags to include in the ADF test I use Swartz's Bayesian information criterium. Further, the graphical presentations of the data presented above have been used to investigate which of the three different models (1) Pure random walk, (2) A random walk with drift and (3) A random walk with drift and trend are most fitting for the analysis. The result of the test is presented in the table below:

Table 1: Test result from stationary test

Variable	Coefficient	Integration order
Ln(real house price) Number of lags	-2.784 0	$I(1)$
Ln(real income) Number of lags	-4.475*** 0	$I(0)$
Real interest rate after tax Number of lags	-1.219 1	$I(1)$
-	-7.473*** 0	$I(0)$
Unemployment Number of lags	-0.376 5	$I(1)$
Ln(housing construction) Number of lags	-4.659*** 0	$I(0)$
Significance: *p < 0.10 **p < 0.05 ***p <0.10		

The test results show that income, expectations and housing construction are integrated of order 0, $I(0)$, meaning that they are stationary. House prices, interest rate and unemployment are integrated of order 1, $I(1)$ and get stationary after the first difference.

8.6. Presentation of the house price model

The following model will be used to analyze the housing market in Oslo:

$$
\begin{aligned}
&\Delta\ln(House\ price)_t \\
&\quad = a_0 + b_1\Delta ln(Income)_t + b_2\Delta Interest\ rate(1-\tau)_t + b_3\Delta Unemployment_t + b_4\Delta Expec_t \\
&\quad + c_1\ln\ (House\ price)_{t-1} + d_1\ln\ (Income)_{t-1} + d_2 Interest\ rate_{t-1} + d_3 Expec_{t-1} \\
&\quad + d_4 Unemployment_{t-1} + d_5\ln\ (Housing\ construction)_{t-1} + \gamma_1 UFS + \gamma_2 Financial\ Crisis \\
&\quad + \gamma_3 S1 + \gamma_4 S2 + \gamma_5 S3 + u_t
\end{aligned}
$$

Where: Δ= first difference, ln=logarithm and u_t= error term. House prices, Income and interest rate are stated in real terms.

This is a one-step error correction model as derived under sub-chapter 7.6. Here, the coefficient estimates b_i are the short-run parameters, c_1 is the error correction term, the coefficient estimates d_i are the long-run parameters and the γ_i coefficient estimates are the five dummy variables described above. This model makes it possible to analyze both short-and long-run dynamics between the dependent variable and the explanatory variables. In addition, an error correction model solves the problem with non-stationary variables and spurious regressions. I therefore find this a fitting model for my analysis of the housing market in Oslo.

In the model I have chosen to include housing construction only as part of the long-run parameters. The reason for this is that it takes time to build new dwellings, and including this variable as part of the short-run dynamics would therefore not make sense. This is not in accordance with derivation of error correction models provided in 7.6, but according to Banerjee, Dolado, Galbraith & Hendry (2003) one is free to omit some variables in the short-term dynamics if this makes more sense for the analysis.

8.6.1. Testing the model

Before I start to analyze the housing market in Oslo I will first test if the model chosen is a good fit for the data. I have already established that the variables are either stationary or integrated of first order. For the model to provide unbiased and efficient estimates the variables need to be cointegrated. Further, I will test for autocorrelation as this is a common problem in time-series analysis.

In order to test for cointegration between the variables, I will use the Engle-Granger approach derived under sub-chapter 7.5. After running the regression, I apply the ADF test to test for stationarity in the error term. Same as for the stationarity tests, I choose to use Swartz's Bayesian information criterium to find number of lags to include in the test. Number of lags included in the test is 0, and the test provides a t-statistic of -7.959. This statistic is significant on the 1% when compared to the critical values developed by Davidson & MacKinnon (1993), and we can conclude that the variables are cointegrated.

Figure 8.9. A graphical presentation of the error terms

The figure above shows a graphical presentation of the error terms both over time, and as a scatter plot. Based on these graphs it do not look like there is any autocorrelation in the error terms. To confirm this, I will use the Ljung-box test derived in sub-chapter 7.4.1. to test for autocorrelation. According to Burns (2002) number of lags included in the test should be relatively small compared to the sample size, and should not exceed 15 percent of the sample size. My sample size consist of 64 variables and I have decided to include 9 lags in the test. The table below shows the result of the test:

Table 2: Test result from Ljung-box test for autocorrelation

	Q-stat	P-value
Error term, u	5.394	0.799

The null hypothesis of the test states that the error term is "white noise", meaning that there is no autocorrelation in the error term. The critical value for the test I find in the χ^2-distribution. As I have incorporated 9 lags in the test, the 5% critical value becomes 16.92. According to the Ljung-box test we can therefore conclude that there is no autocorrelation in the error term, and the OLS estimates from the test will be BLUE.

9.0. Econometric analysis

As specified above, the main objective for writing this thesis is to analyze what drives the price development in the housing market in Oslo in order to answer the following question; "Are there indications pointing towards a bubble in the housing market in Oslo?". In this chapter the house price model presented in chapter 8 will be used to analyze the housing market in Oslo.

9.1. Presenting the regression results from the house price model

Table 3: Regression results from the house price model, standard deviations in parenthesis

Variable	Coefficient	t-value	p-value
Short-run dynamics			
$\Delta In(Income)_t$	0.322** (0.145)	2.217	0.031
$\Delta Interest\ rate(1-\tau)_t$	-0,021*** (0.006)	-3.346	0.002
$\Delta Unemployment_t$	-0.038 (0.025)	-1.529	0.132
$\Delta Expec_t$	0.001 (0.001)	1.354	0.182
Error correction mechanism (λ)			
$\ln(House\ price)_{t-1}$	-0.351*** (0.102)	-3.443	0.001
Long-run dynamics			
$\ln(Income)_{t-1}$	0.350*** (0.136)	2.577	0.013
$Interest\ rate(1-\tau)_{t-1}$	-0.019** (0.007)	- 2.529	0.015
$Unemployment_{t-1}$	-0.055*** (0.016)	-3.516	0.001

$Expec_{t-1}$	0.001** (0.001)	2.030	0.048
$\ln{(Construction)_{t-1}}$	0.011 (0.007)	1.535	0.131
Dummy variables			
UFS	0.089*** (0.029)	3.109	0.003
Financial crisis	-0.064*** (0.018)	-3.496	0.001
S1	0.050*** (0.017)	2.891	0.006
S2	0.043*** (0.011)	3.787	0.001
S3	0.034** (0.016)	2.062	0.044
Constant	-0.638 (0.851)	-0.749	0.457
N		66	
R^2		0.6304	
ADF test		-7.959	
Ljung-box test		5.394	
Significance: *p < 0.10 **p < 0.05 ***p < 0.01			

Table 3 above shows the regression results from the house price model. I have categorized the variables after short-run dynamics, the error correction mechanism, long-run dynamics and dummy variables. The three first categories should be interpreted as derived under sub-chapter 7.6, and the dummy variables should be interpreted as a truth value represented as a numerical value, 0 or 1.

As explained under sub-chapter 6.7, the short-run parameters can be interpreted as direct economic effects. The long-run parameters on the other hand cannot be interpreted as direct economic effects, as we need to calculate how the long-run effect is distributed over future periods. This distribution is decided based on the error correction mechanism. The long-run economic effect can be calculated with the following formula, derived under sub-chapter 7.6:

$$Long-run\ economic\ effect = \frac{-d}{c}$$

Here, d is the long-run parameter and c is the error correction mechanism. As the error correction mechanism is always negative, d has a negative sign in the formula to adjust so that the long-run coefficient do not get an opposite sign from the estimated short-run coefficient. With the use of this formula, and data from table 3, I have calculated the long-run economic effects. The result is presented in table 4 below:

Table 4: Long-run dynamics in the housing market

Variable	**Coefficient**
$\ln{(Income)}_{t-1}$	0.997***
$Interest\ rate(1-\tau)_{t-1}$	-0.054**
$Unemployment_{t-1}$	-0.157***
$Expec_{t-1}$	0.003**
$\ln{(Construction)}_{t-1}$	0.031
Significance: *p < 0.10 **p < 0.05 ***p < 0.01	

These long-run effects can be interpreted as the long-run equilibrium relationship, and it is this table I refer to when I later analyze the long-run dynamics in the housing market. The long-run equilibrium relationship can be interpreted as the balance between supply and demand in the housing market. As the entire economy is not included in this model, the housing price calculated here will not be the actual equilibrium price. I do, however, believe that the fundamental factors included in this model is an important part of how housing prices converge towards equilibrium in the long-run.

Before I start to interpret the models coefficient estimates, it is interesting to investigate how well the model fits the data. The R-squared is presented in table 4 and has a value of 0.63, meaning that the error correction model is describing 63% of the development in housing prices. I find it positive that the explanatory power of the model is high, but not too high, as this would have led to suspicion about a possible spurious regression due to collinearity.

9.2. Interpretation of the models coefficient estimates

In this sub-chapter I will interpret the coefficient estimates of the explanatory variables included in the model. The purpose is to figure out what the most important fundamental explanatory factors for house prices in Oslo are, and to investigate how quickly and strongly house prices react to changes in these factors.

9.2.1. The error correction mechanism

The adjustment parameter (λ) in the error correction model indicates the speed back to equilibrium after a deviation from an estimated long-term equilibrium relationship between housing prices, income, interest rate, unemployment, expectations, and housing construction. For the error correction model to be specified correctly, the adjustment parameter should lie between 0 and 1. The closer towards 0 the parameter is, the longer time the adjustment takes. A parameter equal to 0 means that there is no long-term equilibrium relationship. Further, the adjustment parameter should be negative and significant for the variables to be cointegrated. The adjustment parameter is estimated to be 0.350 and is significant at the 1% level. Further, it has a negative sign. We can therefore conclude that the variables included in the model are cointegrated. According to the model, a deviation from the estimated long-term relationship will be adjusted in with 0.350 percent per quarter. This indicates that a deviation from the equilibrium takes approximately three quarters to adjust back.

9.2.2. Household real disposable income

Household real disposable income is included in the model as an explanatory variable both in the short- and long-run. The income elasticity is calculated to be 0.322 in the short run. This indicates that a 1% increase in households real disposable income will increase housing prices with 0.322% the first quarter, and 1.288% the first year. This coefficient estimate is significant at the 5% level. In the long-run, the income elasticity is calculated to be 0.997. This indicates that a permanent 1% increase in households real disposable income will lead to an increase of 0.977% in the long-term equilibrium price. This coefficient is significant at the 1% level. When interpreting this coefficient estimate, it is important to bear in mind that the data before 2002 is transformed from yearly data, and will therefore not vary within the same year. The lower variation in the income variable for the first 8 quarters is expected to result in less explanatory power of this coefficient estimate. The true impact of household real disposable income is therefore expected to be somewhat higher than the estimate presented here. I still find it important to include this variable, as income is an important fundamental factor for house price development in the literature.

9.2.3. Real interest rate after tax

The real interest rate after tax shows a significant effect on house price development both in the short-and long-run. According to the model, a 1% increase in the real interest after tax will lead to a 2.1% decrease in housing prices the first quarter, and a 8.4% decrease the first year. This effect is significant on the 1% level. In the long-run, a 1% increase in the real interest after tax will lead to a decrease in housing prices of 5.4%. This effect is significant on the 1% level. This result indicates that housing prices react quickly and strongly to changes in the real interest after tax. Further, the results indicate that house prices will rise more in the short term than in the long term if interest rates fall. This phenomenon is referred to as "overshooting" by Jacobsen & Naug (2004), and is not an indication of a house price bubble. Overshooting may, however, have a negative impact on the economy. In this case the overshooting is relatively modest, and a decrease in interest rates is therefore not expected to impact the economy significantly as a result of overshooting. This coefficient estimate has a negative sign which is in accordance with economic theory.

9.2.4. Household expectations

In the literature, household expectations is considered an important fundamental factor explaining the development in housing prices. In the model, household expectations only shows a significant effect on the house price development in the long-run. The long-run effect is, however, small and household expectations cannot be considered to have a big impact on house price development in neither the short- nor the long-run. A permanent positive shift (unit change) in the consumer confidence indicator is only expected to lead to a 0.3% increase in housing prices. I find this result surprising, as I expected household expectations to have a bigger impact on the house price development. One reason for the modest effect of household expectations in the model can be that the estimation periods biggest shock, the financial crisis, is controlled for in a dummy variable. Another reason for this modest result can be that the Norwegian model that favors investment in housing induces a lack of risk perception in the housing market.

9.2.5. Unemployment

Unemployment shows a highly significant effect on house price development in the long-run, but no significant effect on house price development in the short-run. I was a bit surprised about this result, as I expected unemployment to have a significant effect also in the short-run. One reason for this result could possibly be that there is a time-lag in the market reaction to changes in the unemployment level. In the long-run, unemployment is the most important fundamental factor explaining the development in housing prices. According to the model, a permanent increase of a 1% in the unemployment rate will lead to a decline in housing prices of 15.7%. Consequently, the results show that an increase in the unemployment level has a negative effect on housing prices. This is in accordance with economic theory, and the results of previous house price models.

9.2.6. Housing construction

In economic theory, housing construction is considered an important fundamental factor explaining the development in housing prices. Despite this, the house price model shows no significant effect of housing construction on the development in housing prices. Further, the coefficient estimate for housing construction has a positive sign, which is not in accordance with economic theory. As described in sub-chapter 3.2.2, an increase in residential investment should lead to decreasing housing prices. One reason why the coefficient estimate shows an insignificant effect on the development in housing prices, may be because building work started in square meters is an insufficient measure of residential investment. First, this measure do not account for the total residential investment in a period, but only the residential investment that is started up. Secondly, housing construction measured in number of square meters instead of in monetary value, may potentially provide a skewed picture of the total resources invested in housing construction. One explanation for the positive impact on housing prices, and not a negative as predicted by theory, may be the low level of housing construction. As described in sub-chapter 6.3.1. there has been a supply deficit in the entire period of analysis. When construction projects finally get started this may therefore lead to an increased demand in the market, as more people want to participate in the housing market. One could possibly argue that housing construction should not be included in the model due to the fact that it has an insignificant effect and a wrong sign. I have, however, decided to keep this factor in the model, as economic theory and earlier studies clearly points toward residential investment being an important factor for house price development.

9.2.7. Dummy variables

All the dummy variables included in the model are significant at a 1% level, except for S3 which is significant at the 5% level. This therefore indicates that all of the dummy variables should be included in the model. The dummy variable for the financial crisis has a negative sign, indicating that the financial crisis had a negative effect on the housing prices in Oslo. This is interesting, but not unexpected. All the season variables have a positive sign, indicating that the housing prices are higher in the spring, summer and fall season than in the winter season. This makes sense, as the winter season is the season when there is the least amount of dwellings put out on the market for sale.

9.3. Summary and discussion about the model

The coefficient estimates are for the mostly statistically significant and in accordance with what we expect from economic theory. The exceptions are the lagged variables of unemployment and expectations, and the coefficient estimate for housing construction. The most important explanatory factor for the development in housing prices in the short-run is the real interest rate after tax. According to the model a 1% increase in interest rate would lead to a 8.4% decrease in housing prices. This is however only hypothetical, as there is no indication of a rate increase in the year to come. The most important explanatory factor for the development in housing prices in the long-run is unemployment. According to the model, a 1% increase in the unemployment rate will lead to a decline in housing prices of 15.7%.

The ADF test is statistical significant on the 1% level, and the adjustment mechanism is negative and significant. This confirms that the variables included in the model are cointegrated, and consequently we can conclude that the error correction mechanism is valid. Based on economic literature and previous house price models, this is an expected result. Another common problem in time-series analysis is spurious regressions. As I have detected that the variables are cointegrated, and are either stationary or integrated of first order, this means that we avoid the problem of spurious results. Further, the Ljung-box test and a graphical presentation of the error term shows no indications of autocorrelation in the error term. The error correction model does therefore avoid all the most common problems in time-series analysis

If I should critique my own model, it is especially two important points that may create problems. First of all, the observation period of 16 years (64 quarters) is quite short when comparing to previous studies. A longer data set would probably yield a more robust result. I have met some limitations when it comes to available data as I am studying the development in housing prices in Oslo and not on country basis. This is the reason why my data set is so short, and why some of the variables have a little different characteristics than they should ideally have. Secondly, it is a weakness that housing construction has an insignificant effect in the model, and that this coefficient estimate has the wrong sign. As I expect the result of the regression to become spurious if I omit this variable, I have decided to keep it in the model.

One strength with the model is that the period of observation includes an economic shock through the financial crisis, and that it seems like the model is handling this shock pretty well. The explanatory power of the model is further quite good, with an R-squared of 63%. The model do therefore fit the data well, and despite the fact that housing construction is insignificant I find that the model reflects economic theory on house price development well.

10. Conclusion and final remarks

The Norwegian housing market has experienced an excessive house price growth in recent years, and the market is in a boom period. The highest price growth is seen in Oslo, where we saw a price increase in 2016 alone of 25 percent. The population growth in Oslo has been high, much due to migration and urbanization. Further, the Norwegian economy has been characterized with low unemployment, income growth and low interest rates. This has driven the housing demand in Oslo. Due to demanding construction standards and regulation on land use, housing construction has not met this increase in housing demand, and a gap between supply and demand has emerged. The housing prices in Oslo seem inflated when studying the historical development in real house prices, the price-to-construction costs ratio and the price-to-rent ratio. The question is whether this price increase can be explained by development in underlying fundamental factors, or whether this price increase is a speculative bubble building up.

In order to analyze what drives the price development in the housing market in Oslo, and to investigate if there are indications pointing towards a bubble in the housing market, I developed an econometric house price model specific for the housing market in Oslo. I found that interest rate and unemployment are the two most important fundamental factors driving the house price development in Oslo. Interest rate has a significant effect on housing prices both in the short-and long-run, while unemployment only has a significant effect in the long-run. The results from the regression model do not indicate that there is a housing bubble in Oslo, as I find that much of the price development in the housing market can be explained by development in underlying fundamental factors such as income, unemployment, household expectations, interest rate and housing construction. The explanatory variables chosen for the analysis explains 63 percent of the price development in Oslo in the period of analysis.

It is, however, important to emphasize that there are limitations to the use of regression analysis to identify bubbles in the market. The most important limitation to my house price model is that it do not capture the effect of all variables driving the development in housing prices. Further, the data set chosen is quite short, and a longer data set would probably yield a more robust result. I do, however, find the model to provide valuable insight into how different fundamental factors affect the development in housing prices.

Even though I find no evidence pointing towards a housing bubble in Oslo, this does not necessarily mean that the housing prices will not decline in the near future. The economic situation is uncertain both in Norway and in the world as a whole, and the oil plunge in 2014 showed how dependent the Norwegian economy is on the oil industry. The most important fundamental factors driving the price development in Oslo are unemployment and interest rate, and negative changes in one of these factors is expecting to lead to falling house prices. How the economic situation develops the next years is therefore crucial for the development in the housing prices.

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Appendices

Appendix 1: Gap between new households and construction

	Population	Completed dwellings	Households	New households	Gap
2000	507467	1035	267088		
2001	508726	818	267751	663	155
2002	512589	1685	269784	2033	-348
2003	517401	1618	273757	3973	-2355
2004	521886	3470	276130	2373	1097
2005	529846	4049	280342	4212	-163
2006	538411	3960	286389	6047	-2087
2007	548617	3709	293378	6989	-3280
2008	560484	2524	301335	7957	-5433
2009	575475	3447	309395	8060	-4613
2010	586860	2095	312160	2764	-669
2011	599230	1333	317053	4893	-3560
2012	613285	3861	321092	4039	-178
2013	623966	3287	326684	5592	-2305
2014	634463	3349	322062	-4621	7970
2015	647676	2041	328770	6707	-4666
2016	658390	2393	332520	3751	-1358

	Persons per household
1990	1,85
2001	1,9
2005	1,89
2006	1,88
2007	1,87
2008	1,86
2009	1,86
2010	1,88
2011	1,89
2012	1,91
2013	1,91
2014	1,97
2015	1,97
2016	1,98

Appendix 2: Rent index and CPI

	Rent Oust (1970=100)	CPI (2015=100	Rent Oust (1992=100)	CPI (1992=100
1992	649,38	63,40	100,00	100,00
1993	661,77	64,80	101,91	102,21
1994	682,70	65,70	105,13	103,63
1995	749,43	67,30	115,41	106,15
1996	784,68	68,20	120,84	107,57
1997	906,86	69,90	139,65	110,25
1998	990,89	71,50	152,59	112,78
1999	1050,37	73,20	161,75	115,46
2000	1105,97	75,50	170,31	119,09
2001	1149,50	77,70	177,01	122,56
2002	1137,64	78,70	175,19	124,13
2003	1055,46	80,70	162,53	127,29
2004	1024,82	81,00	157,82	127,76
2005	1070,54	82,30	164,86	129,81
2006	1108,87	84,20	170,76	132,81
2007	1291,71	84,80	198,91	133,75
2008	1386,02	88,00	213,44	138,80
2009	1354,24	89,90	208,54	141,80
2010	1437,43	92,10	221,35	145,27
2011	1513,64	93,30	233,09	147,16
2012	1588,73	93,90	244,65	148,11
2013	1641,27	95,90	252,74	151,26
2014	1676,78	97,90	258,21	154,42
2015	1749,92	100,00	269,48	157,73
2016	1839,92	103,60	283,33	163,41

*Rent Oust are based on numbers from Boligbygg KF Oslo from 2009-2016

	Boligbygg Oslo KF	
	Rent	Change
2008	2137	
2009	2088	-2,29 %
2010	2216	6,14 %
2011	2334	5,30 %
2012	2449	4,96 %
2013	2530	3,31 %
2014	2585	2,16 %
2015	2698	4,36 %
2016	2837	5,14 %

Appendix 3: DTI Ratio

	Real average debt	Real average gross income	Real DTI ratio
2000q1	105207	99487	1,06
2000q2	104416	98738	1,06
2000q3	104093	98433	1,06
2000q4	103137	97530	1,06
2001q1	113906	94453	1,21
2001q2	112596	93367	1,21
2001q3	113759	94331	1,21
2001q4	113320	93967	1,21
2002q1	121631	103689	1,17
2002q2	120909	103073	1,17
2002q3	121012	103161	1,17
2002q4	119591	101950	1,17
2003q1	126457	100989	1,25
2003q2	128607	102705	1,25
2003q3	129142	103133	1,25
2003q4	128500	102620	1,25
2004q1	142153	108995	1,30
2004q2	141334	108368	1,30
2004q3	141392	108412	1,30
2004q4	140640	107836	1,30
2005q1	157525	119441	1,32
2005q2	155802	118135	1,32
2005q3	155487	117896	1,32
2005q4	154550	117186	1,32
2006q1	171175	102153	1,68
2006q2	169076	100900	1,68
2006q3	169009	100860	1,68
2006q4	167618	100029	1,68
2007q1	184794	111846	1,65
2007q2	183774	111228	1,65
2007q3	183991	111360	1,65
2007q4	180290	109120	1,65

	Real average debt	Real average gross income	Real DTI ratio
2008q1	186997	113721	1,64
2008q2	186497	113417	1,64
2008q3	184106	111963	1,64
2008q4	182387	110917	1,64
2009q1	189925	109318	1,74
2009q2	188167	108306	1,74
2009q3	188167	108306	1,74
2009q4	187127	107707	1,74
2010q1	192565	111029	1,73
2010q2	191453	110388	1,73
2010q3	192845	111191	1,73
2010q4	190970	110110	1,73
2011q1	199319	113360	1,76
2011q2	198043	112633	1,76
2011q3	199391	113400	1,76
2011q4	198750	113036	1,76
2012q1	209574	116536	1,80
2012q2	209128	116289	1,80
2012q3	210621	117119	1,80
2012q4	208169	115755	1,80
2013q1	219184	119079	1,84
2013q2	217203	118002	1,84
2013q3	216525	117634	1,84
2013q4	215479	117066	1,84
2014q1	222887	121186	1,84
2014q2	221365	120358	1,84
2014q3	220088	119664	1,84
2014q4	219270	119219	1,84
2015q1	228716	127452	1,79
2015q2	226578	126260	1,79
2015q3	225749	125798	1,79
2015q4	223813	124720	1,79

Appendix 4: Real House Price Index

	House price index (1912=100)	House price index (1998=100)	CPI (1998=100)	Real house price index (1998=100)
841	38,09	0,88	1,68	52,52
842	32,72	0,76	1,63	46,50
843	35,22	0,82	1,63	50,09
844	39,23	0,91	1,61	56,61
845	29,79	0,69	1,70	40,76
846	56,61	1,31	1,79	73,36
847	40,55	0,94	2,05	45,97
848	31,32	0,73	1,84	39,49
849	34,38	0,80	1,78	44,71
850	34,56	0,80	1,72	46,65
851	37,55	0,87	1,73	50,40
852	25,86	0,60	1,82	32,94
853	37,24	0,86	1,89	45,62
854	38,10	0,88	2,08	42,42
855	37,85	0,88	2,19	40,02
856	42,31	0,98	2,37	41,48
857	57,72	1,34	2,35	56,99
858	67,77	1,57	2,07	75,79
859	68,55	1,59	2,08	76,59
860	60,89	1,41	2,18	64,93
861	64,00	1,48	2,23	66,47
862	51,17	1,19	2,18	54,44
863	43,11	1,00	2,16	46,25
864	47,19	1,09	2,13	51,28
865	57,71	1,34	2,07	64,55
866	55,67	1,29	2,18	59,25
867	39,80	0,92	2,25	41,05
868	52,00	1,21	2,32	52,02
869	55,39	1,29	2,20	58,47
870	50,37	1,17	2,11	55,33
871	56,95	1,32	2,13	61,93
872	52,54	1,22	2,26	53,82
873	54,90	1,27	2,36	54,00
874	73,11	1,70	2,48	68,38
1875	78,24	1,82	2,43	74,62
1876	90,42	2,10	2,37	88,66
1877	79,79	1,85	2,39	77,61
1878	77,18	1,79	2,27	78,86
1879	73,45	1,70	2,13	80,10
1880	83,59	1,94	2,21	87,93
1881	68,00	1,58	2,21	71,40
1882	84,00	1,95	2,22	87,90
1883	95,98	2,23	2,24	99,57
1884	64,38	1,49	2,15	69,46
1885	70,85	1,64	2,06	79,84
1886	66,71	1,55	1,98	78,29
1887	69,43	1,61	1,93	83,33
1888	71,08	1,65	1,95	84,65
1889	71,81	1,67	1,98	84,28
1890	83,72	1,94	2,01	96,86
1891	88,73	2,06	2,10	98,00
1892	87,26	2,02	2,07	97,87
1893	83,85	1,95	1,96	99,18
1894	93,03	2,16	1,91	113,12
1895	90,54	2,10	1,91	110,09
1896	104,85	2,43	1,95	124,98
1897	110,83	2,57	1,91	134,49
1898	125,17	2,90	1,97	147,77
1899	156,00	3,62	2,07	174,83
1900	114,38	2,65	2,16	122,96
1901	112,16	2,60	2,12	122,97
1902	122,27	2,84	2,14	132,86
1903	93,68	2,17	2,18	99,48
1904	63,50	1,47	2,18	67,73
1905	75,14	1,74	2,24	77,82
1906	75,83	1,76	2,22	79,07
1907	73,01	1,69	2,28	74,29
1908	68,90	1,60	2,27	70,28

	House price index (1912=100)	House price index (1998=100)	CPI (1998=100)	Real house price index (1998=100)
1909	65,74	1,53	2,21	68,97
1910	92,12	2,14	2,29	93,27
1911	89,15	2,07	2,34	88,44
1912	100,00	2,32	2,48	93,42
1913	95,95	2,23	2,58	86,36
1914	102,86	2,39	2,61	91,55
1915	97,50	2,26	2,98	75,83
1916	119,53	2,77	3,56	78,01
1917	129,07	2,99	4,42	67,80
1918	148,61	3,45	6,21	55,57
1919	160,17	3,72	6,64	56,00
1920	171,24	3,97	7,73	51,38
1921	154,60	3,59	7,17	50,04
1922	152,36	3,53	6,01	58,82
1923	168,61	3,91	5,65	69,27
1924	154,78	3,59	6,19	58,01
1925	167,62	3,89	6,30	61,74
1926	165,76	3,85	5,36	71,78
1927	166,96	3,87	4,81	80,45
1928	158,40	3,67	4,49	81,86
1929	162,35	3,77	4,31	87,43
1930	146,48	3,40	4,16	81,63
1931	180,03	4,18	3,95	105,85
1932	175,21	4,07	3,87	104,94
1933	173,83	4,03	3,84	105,10
1934	168,05	3,90	3,84	101,60
1935	179,08	4,15	3,91	106,26
1936	202,99	4,71	4,02	117,20
1937	190,48	4,42	4,31	102,58
1938	190,75	4,43	4,45	99,39
1939	207,66	4,82	4,49	107,33
1940	203,84	4,73	5,25	90,09
1941	214,70	4,98	6,16	80,89
1942	247,49	5,74	6,54	87,77

	House price index (1912=100)	House price index (1998=100)	CPI (1998=100)	Real house price index (1998=100)
1943	149,82	3,48	6,69	51,95
1944	197,15	4,57	6,78	67,51
1945	293,57	6,81	6,90	98,71
1946	228,41	5,30	7,07	74,99
1947	227,22	5,27	7,10	74,25
1948	223,88	5,19	7,05	73,68
1949	215,19	4,99	7,08	70,57
1950	217,77	5,05	7,43	67,97
1951	226,61	5,26	8,60	61,13
1952	224,30	5,20	9,38	55,51
1953	282,44	6,55	9,58	68,38
1954	214,55	4,98	9,98	49,90
1955	283,62	6,58	10,08	65,31
1956	271,02	6,29	10,46	60,12
1957	292,76	6,79	10,76	63,13
1958	315,41	7,32	11,30	64,76
1959	278,63	6,46	11,56	55,93
1960	324,47	7,53	11,60	64,90
1961	316,22	7,34	11,85	61,91
1962	348,74	8,09	12,48	64,86
1963	357,32	8,29	12,78	64,85
1964	390,96	9,07	13,53	67,02
1965	417,03	9,68	14,10	68,62
1966	461,01	10,70	14,56	73,47
1967	527,58	12,24	15,23	80,40
1968	559,16	12,97	15,75	82,37
1969	581,26	13,49	16,22	83,16
1970	578,03	13,41	17,94	74,75
1971	599,81	13,92	19,06	73,02
1972	725,49	16,83	20,44	82,34
1973	705,86	16,38	21,96	74,58
1974	755,37	17,53	24,03	72,95
1975	720,99	16,73	26,83	62,34

	House price index (1912=100)	House price index (1998=100)	CPI (1998=100)	Real house price index (1998=100)
1976	757,15	17,57	29,29	59,97
1977	967,71	22,45	31,96	70,25
1978	944,47	21,91	34,57	63,39
1979	1007,08	23,37	36,20	64,54
1980	1115,51	25,88	40,15	64,46
1981	1480,85	34,36	45,63	75,29
1982	1647,00	38,21	50,80	75,22
1983	1935,79	44,91	55,08	81,55
1984	2212,44	51,33	58,55	87,67
1985	2346,43	54,44	61,86	88,01
1986	2821,04	65,45	66,31	98,71
1987	3295,83	76,47	72,09	106,07
1988	3287,06	76,26	76,91	99,16
1989	2942,66	68,27	80,40	84,92
1990	2561,31	59,42	83,72	70,98
1991	2404,51	55,79	86,58	64,43
1992	2261,99	52,48	88,62	59,22
1993	2308,96	53,57	90,64	59,10
1994	2549,03	59,14	91,91	64,35
1995	2759,54	64,02	94,16	68,00
1996	3087,98	71,64	95,33	75,15
1997	3656,99	84,85	97,79	86,76
1998	4310,19	100,00	100,01	99,99
1999	5004,47	116,11	102,34	113,45
2000	5756,70	133,56	105,50	126,60
2001	6047,52	140,31	108,68	129,10
2002	6708,26	155,64	110,08	141,38
2003	6800,42	157,78	112,81	139,86
2004	7448,57	172,81	113,33	152,48
2005	8227,39	190,88	115,06	165,90
2006	9474,34	219,81	117,74	186,69
2007	10604,11	246,02	118,60	207,44
2008	10234,35	237,45	123,07	192,94

	House price index (1912=100)	House price index (1998=100)	CPI (1998=100)	Real house price index (1998=100)
2009	10263,50	238,12	125,73	189,39
2010	11142,12	258,51	128,75	200,78
2011	12241,21	284,01	130,43	217,75
2012	13246,92	307,34	131,35	233,99
2013	13799,95	320,17	134,15	238,67
2014	15668,21	363,52	136,87	265,60
2015	17503,21	406,09	139,84	290,39
2016	21999,38	510,40	144,80	352,49

Appendix 5: Price-to-construction costs ratio

	House prices (2015=100)	House prices (2000=100)	Construction costs (2000=100)	P/CC ratio
2000q1	39	99	99	1,00
2000q2	40	104	99	1,05
2000q3	39	100	100	0,99
2000q4	38	97	102	0,96
2001q1	41	104	104	1,01
2001q2	42	107	104	1,03
2001q3	42	108	105	1,03
2001q4	42	107	106	1,01
2002q1	44	113	107	1,05
2002q2	45	116	108	1,08
2002q3	44	114	109	1,05
2002q4	43	111	110	1,01
2003q1	43	111	111	1,00
2003q2	43	110	111	0,99
2003q3	44	113	112	1,01
2003q4	45	114	112	1,02
2004q1	47	120	113	1,06
2004q2	48	122	115	1,07
2004q3	49	125	116	1,08
2004q4	49	127	116	1,09
2005q1	51	132	118	1,12
2005q2	52	133	118	1,12
2005q3	53	137	119	1,15
2005q4	54	138	120	1,15
2006q1	57	145	121	1,20
2006q2	59	153	122	1,25
2006q3	62	161	123	1,30
2006q4	63	163	126	1,29
2007q1	67	173	129	1,34
2007q2	68	175	132	1,33
2007q3	68	175	133	1,31
2007q4	65	168	136	1,24
2008q1	66	170	138	1,23
2008q2	67	171	139	1,23
2008q3	65	166	140	1,19
2008q4	59	153	142	1,08
2009q1	62	159	142	1,12
2009q2	66	170	142	1,19
2009q3	69	177	143	1,24
2009q4	68	176	145	1,22
2010q1	70	179	146	1,23
2010q2	72	185	148	1,26
2010q3	73	188	148	1,27
2010q4	73	188	150	1,26
2011q1	77	199	151	1,31
2011q2	79	203	153	1,33
2011q3	80	207	153	1,35
2011q4	80	206	155	1,33
2012q1	83	213	156	1,36
2012q2	85	219	157	1,39
2012q3	88	225	158	1,42
2012q4	87	223	160	1,39
2013q1	89	229	161	1,43
2013q2	90	231	162	1,43
2013q3	88	227	163	1,39
2013q4	86	220	164	1,34
2014q1	87	224	165	1,35
2014q2	91	234	168	1,39
2014q3	92	237	169	1,41
2014q4	93	238	169	1,40
2015q1	97	251	171	1,47
2015q2	100	257	172	1,50
2015q3	102	261	173	1,51
2015q4	101	260	173	1,50
2016q1	107	273	174	1,57
2016q2	113	289	176	1,64
2016q3	120	311	177	1,76
2016q4	123	323	178	1,82

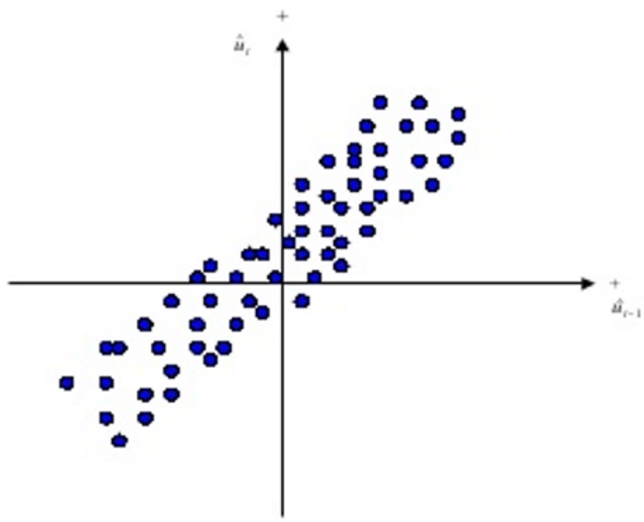
Appendix 6: Price-to-rent ratio

	House price index (1998=100)	House price index (1970=100)	Rent Oust (1970=100)	P/R ratio
1970	13,41	100,00	100,00	1,00
1971	13,92	103,77	109,33	0,95
1972	16,83	125,51	119,61	1,05
1973	16,38	122,11	127,30	0,96
1974	17,53	130,68	137,73	0,95
1975	16,73	124,73	151,36	0,82
1976	17,57	130,99	167,02	0,78
1977	22,45	167,42	173,28	0,97
1978	21,91	163,39	218,00	0,75
1979	23,37	174,23	237,68	0,73
1980	25,88	192,99	247,83	0,78
1981	34,36	256,19	298,61	0,86
1982	38,21	284,93	342,47	0,83
1983	44,91	334,90	357,94	0,94
1984	51,33	382,76	375,75	1,02
1985	54,44	405,94	432,01	0,94
1986	65,45	488,05	532,53	0,92
1987	76,47	570,19	710,40	0,80
1988	76,26	568,67	765,66	0,74
1989	68,27	509,09	685,18	0,74
1990	59,42	443,11	645,64	0,69
1991	55,79	415,99	643,06	0,65
1992	52,48	391,33	649,38	0,60
1993	53,57	399,46	661,77	0,60
1994	59,14	440,99	682,70	0,65
1995	64,02	477,41	749,43	0,64
1996	71,64	534,23	784,68	0,68
1997	84,85	632,67	906,97	0,70
1998	100,00	745,67	990,89	0,75
1999	116,11	865,79	1050,37	0,82
2000	133,56	995,92	1105,97	0,90
2001	140,31	1046,24	1149,50	0,91
2002	155,64	1160,54	1137,64	1,02
2003	157,78	1176,49	1055,46	1,11
2004	172,81	1288,62	1024,82	1,26
2005	190,88	1423,36	1070,54	1,33
2006	219,81	1639,08	1108,87	1,48
2007	246,02	1834,54	1291,71	1,42
2008	237,45	1770,57	1386,02	1,28
2009	238,12	1775,61	1354,28	1,31
2010	258,51	1927,61	1437,43	1,34
2011	284,01	2117,76	1513,61	1,40
2012	307,34	2291,75	1588,69	1,44
2013	320,17	2387,42	1641,27	1,45
2014	363,52	2710,64	1676,72	1,62
2015	406,09	3028,10	1749,83	1,73
2016	510,40	3806,11	1839,92	2,06

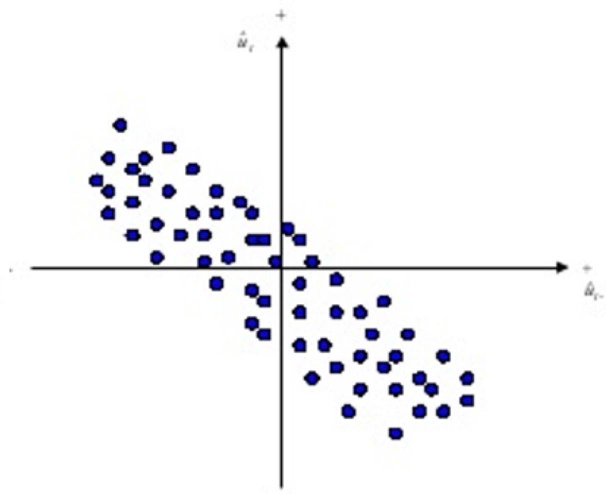
Appendix 7: The graphical method for identifying autocorrelation

A scatter plot can be sued to investigate if we see a systematic pattern of the error terms, or if the error terms seem randomly distributed. If we see signs of a pattern in the graphical investigation it is necessary to conduct statistic tests to test for autocorrelation. Under follows a graphical presentation taken from Brooks (2002).

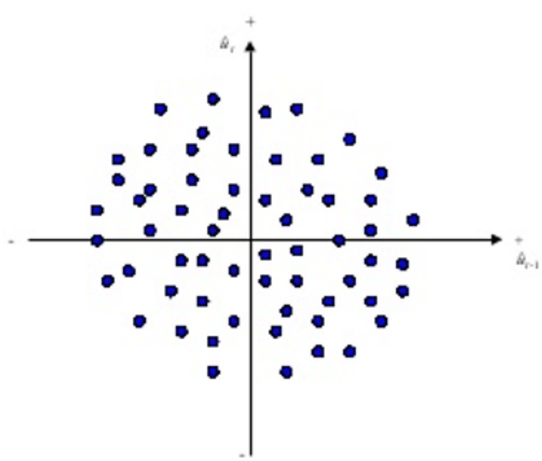
Positive autocorrelation



Negative autocorrelation



No autocorrelation:



Appendix 8: Regression coefficients from expectations model

Variable	Coefficient
$\Delta Interest\ rate_t$	-0.097 (1.582)
$\Delta Unemployment_t$	-10.513 (7.622)
$Expec_{t-1}$	-0.303*** (0.090)
$Interest\ rate_{t-1}$	0.287 (1.145)
$Unemployment_{t-1}$	3.458** (1.517)
S1	14.769*** (4.542)
S2	6.497** (0.048)
S3	13.768*** (4.919)
Constant	-16.440* (8.748)
N	67
R^2	0.355
Adjusted R^2	0.266
Significance: *p<0.10 **p<0,05 ***p <0,10	

Appendix 9: Correlation matrix

	Correlation matrix									
	House price	Income	Interest rate	Unempploy-ment	Construction	Population change	Share price	Net migration	Debt	Expec
ouse price	1,00	0,95	-0,64	-0,22	0,23	0,37	0,86	0,28	0,97	-0,09
come	0,95	1,00	-0,68	-0,06	0,21	0,31	0,80	0,22	0,97	-0,16
terest rate	-0,64	-0,68	1,00	-0,35	-0,31	-0,37	-0,56	-0,28	-0,61	0,00
nemployment	-0,22	-0,06	-0,35	1,00	0,15	-0,07	-0,39	-0,07	-0,23	0,49
onstruction	0,23	0,21	-0,31	0,15	1,00	0,04	0,17	0,02	0,16	-0,12
opulation hange	0,37	0,31	-0,37	-0,07	0,04	1,00	0,40	0,97	0,38	0,00
hare price	0,86	0,80	-0,56	-0,39	0,17	0,40	1,00	0,32	0,83	-0,07
et migration	0,28	0,22	-0,28	-0,07	0,02	0,97	0,32	1,00	0,30	-0,01
ebt	0,97	0,97	-0,61	-0,23	0,16	0,38	0,83	0,30	1,00	-0,11
xpec	-0,09	-0,16	0,00	0,49	-0,12	0,00	-0,07	-0,01	-0,11	1,00