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House Price Dynamics: Analysis of the Oslo Market

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Abstract

In this paper we empirically examine the house price dynamics in the Oslo market. Housing prices in Oslo have been a searing topic in the last couple of years, thus, we believe this will be an important contribution to the literature. First, we will examine how the price to rent ratio together with the extrapolative expectations explain the housing prices in Oslo today. In addition, we want to look at all the macro-economic factors and test how well they explain the housing prices. From the Granziera & Kozicki (2012) approach we simulate the price to rent ratio with very good results. This is further backed up by applying the Vector Error Correction framework which finds that in both the long and the short-run we find explanatory effects of extrapolative expectations towards the price to rent ratio. These explanatory effects are also found in other certain macro-economic variables.

Key words: Extrapolative Expectations, Housing Market, Price to Rent Ratio, Vector Error Correction Model

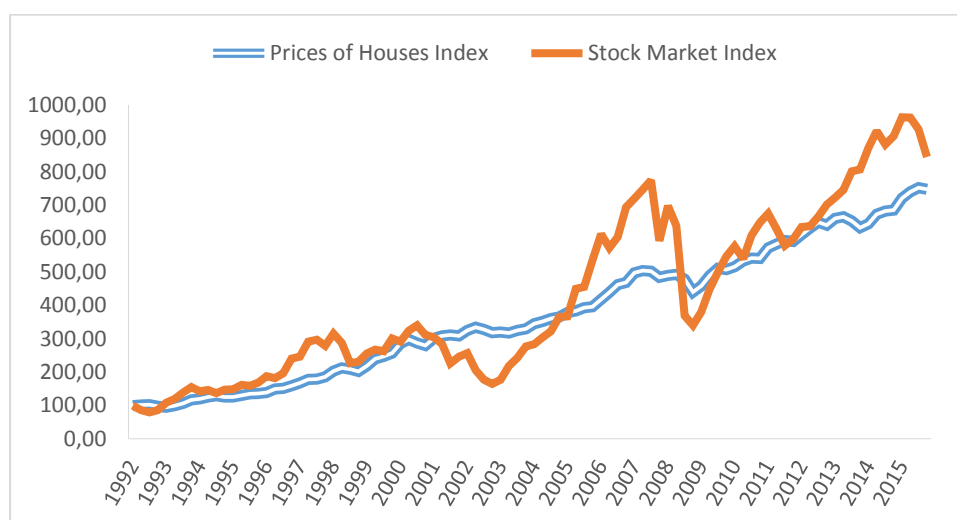
1. INTRODUCTION

1.1. Motivation and Objectives

With a steadily increasing housing price over the last years, the predictions regarding the Norwegian housing market, especially for Oslo, gradually become more valid. Fuelled by a low credit cost and a high demand, we see a constantly increasing market.

First of all, the good abnormal returns present in the last two decades on the Oslo real estate market have made investors put their money more in the housing market instead of the stock market. Both markets have increased at the same pace, and with sharp ratios of 0.72 and 0.46 we can easily understand why a mean variance investor would prefer the housing market, which is much less volatile (see Figure 1).

Figure 1 Real Estate Market vs Stock Market



In the stock market we typically have a buyer and a seller, both having different views on the future growth of the stock. Hence, the seller and the buyer trade based on bearish and bullish opinions of the stock's price, which will make them settle at an equilibrium price. However, in the housing market the sellers might be trading within the same market, meaning they have a bullish perspective of the future price growth. This situation will make the prices inflated as both parties expect to be fairly compensated from their future expectations.

According to Mikalsen & Bjørklund (2016) there is a trend in the housing market where buyers tend to purchase a new house before they have sold their old one. Thus, several houses are kept off the market, limiting the available supply side and leading to higher artificial pressure on the demand side. Homeowners (investors) hereby keep their properties for a longer period of time, selling their old house later on, in September rather than in March, thus expecting to get an appreciation during these extra six months which under traditional circumstances they would not have been able to receive. This emphasizes our belief of extremely high expectations within the housing market.

The method introduced by Granziera & Kozicki (2012), where they test for expectations that are not entirely rational can explain the recent development in price to rent ratios. The analysis was conducted on the American housing market, which we believe was fuelled by unrealistic high expectations. Norway is in a similar state considering it has had a high economic growth ever since they found oil in the 1960's. This has created a highly optimistic generation with high expectations to further growth. Therefore, the aim of our paper is to conduct a similar analysis on the Norwegian market which we believe is central to an enhanced understanding of the current state of the Norwegian housing market in Oslo. We will do this by using a Lucas tree model which will explain the sample average of the price to rent ratio. To take into account the volatility we will consider one fundamental model and two models of extrapolative expectations developed by Lansing (2006 and 2010) and further used in Granziera & Kozicki (2012).

Stiglitz (1990) stated that expectations is one of the most important factors contributing to housing prices. Expectations is what an agent believes will happen in the future, meaning that it affects his or hers willingness to pay for a property. Extrapolative expectations are expectations based on past prices in order to assume futures prices. Assumptions drawn from past prices can lead to irrational levels when agents do not account for past expectations made by previous owners. Even though several studies have been conducted on the Norwegian market with contradictory results, up to our knowledge, the models we use in this paper have not been applied on the Norwegian market.

1.2. Research Question

The aim of our paper is to understand the composition of housing prices and to see whether extrapolative expectations are an important factor regarding the prices in the Oslo housing market. This should reveal some information regarding rational or irrational expectations of this market. The effect of the expectations on the real estate market should be seen in the long run, thus our analysis will be performed quarterly, from 1992 until 2015. In order to complete the study, we also want to match these expectations with macroeconomic variables to understand which yields the best results and affects the housing prices. However, since we have both appraisal-based and macro-economic variables we might encounter autocorrelation and high multicollinearity among our variables, thus making it difficult to test the relationship between price to rent and its determinants.

1.3. Contributions

We contribute to the literature in two ways. First, we conduct an analysis on the Oslo housing market with regards to price to rent ratio and extrapolative expectations through the method presented in Granziera & Kozicki (2012). This will provide a better understanding of how expectations affected price to rent ratios in the last years. Moreover, it will show that extrapolative expectations, added into an asset pricing model where rental income is the only contributing factor of house prices, can predict the development of the actual price to rent.

Our second contribution is an additional analysis performed through a Vector Error Correction Model, where we test traditional macro-economic variables along with extrapolative expectations against our dependent variable price to rent. This will give us a comparison of what factors have the highest amount of influence on the price to rent ratio. The results will show how extrapolative expectations influence price to rent ratio both in the short and long-run. Even though this is a different way of analysing the housing market, we expect at least the traditional macro-economic variables to behave in accordance with past literature.

1.4. Thesis Outline

This paper is structured into four parts. Subsequently Introduction, in Chapter 2 we attempt to identify and review the key studies that are relevant to our subject. Therefore, large quantities of theoretical and empirical research related to financial bubbles and asset pricing is organized to make an overview of relevant research towards our field of study. Chapter 3 presents our research hypothesis along with the methodology used to provide our findings. Chapter 4 presents information about our data and variables, also describing the sources and motivation for selecting them. In Chapter 5, we present our empirical results divided into two different subsections, with the Granziera & Kozicki (2012) model first, followed up by an additional analysis conducted with a VECM model.

2. Literature Review

2.1. Introduction to the housing market

In the recent years, more attention has been paid to the housing market, especially in Oslo and Norway, but also in the rest of the world. The reason for that is mostly due to the big crash in the economy and in the housing markets in several countries during the financial crisis in 2007-2009. When it comes to Oslo and Norway, it is important to mention that this market was hardly affected by the last crisis, and that the Norwegian market has experienced a steady growth in housing prices (Heien & Minge, 2010).

Fluctuations in house prices can have a very strong impact on the real economic activity. Houses or real estate in general are the most important component of a household's wealth, thus changes in house prices can affect household's capital and expenditures (Granziera & Kozicki, 2012). The housing market has a great impact on the economy, especially through the financial systems; that is why the major fall and collapse of the US housing prices has been considered to be the main reason for the economic and financial crisis in 2007-2009 (Granziera & Kozicki, 2012).

2.2. Empirical research regarding the housing market

In recent years, studies regarding dynamic house price models have increased. Most of these studies have been conducted for the USA housing market because

of the crisis in 2007-2009. Increased value of houses is an important factor for the real economy. Increased house prices will create a higher level of wealth for households which will allow them to take on larger amounts of debt, thus increasing the demand in the housing market as illustrated by Kiyotaki & Moore (1997). One common explanation for a boom in the housing market is easily available credit and low real interest rates which substantially boosted housing demand and prices (Himmelberg, Mayer, & Sinai, 2005). Abraham & Hendershott (1996) documented that there is a clear correlation between prices and location. They find that there is a substantial difference among inland and coastal properties, which makes it clear that location of the properties should also be factored in as a variable towards the house prices.

Some papers argued that liquidity limitations can also clarify the excessive sensitivity of house prices with regards to income shocks ((Stein, 1995) and (Ortalo & Rady, 1999)). They strengthen the theory about liquidity constraints although it is unlikely that they explain why volatility differs across locations.

There is also a good reason to believe that the housing market is less efficient than the financial markets, as it is affected by large transaction costs, tax considerations and so forth. Numerous studies on the housing market highlight three main drivers: macroeconomic drivers, institutional/geographic factors and funding arrangements. This is documented by Hofmann (2003), Herring & Wachter (1999), Hilbers, Lei, & Zacho (2001), although Shiller R. (2006) has argued that mass psychology is the most important mechanism driving the prices.

Eyster & Rabin (2010) assume that individuals are imperfect and that homebuyers are naive, meaning that they rationally calculate the correct price given their belief about the demand and growth in the market. They forget to factor in the past buyers, such as themselves, that also used prices to strengthen their price assumptions. This results in a situation where buyers use an estimate that leads to a misunderstanding of past prices.

The Efficient Market Hypothesis suggests that bubbles cannot exist. In a perfectly rational environment, Diba & Grossman (1987) state that a bubble could only exist if the planning horizon of the economic agents is infinite. Stiglitz (1990) argued that if individuals are rational they would foresee the date when the bubble

would burst and sell the asset before that, lowering prices. Thus, this price fall would be foreseen, and bubbles would not exist. Hence, there is reason to believe that investors in the housing market are acting irrationally.

Chow (1989) studied the movements of the US stock prices and interest rates and found that an asset pricing model with adaptive expectations surpasses a similar model with rational expectations. Huh & Lansing (2000) show that a backward looking expectation model captures a better picture of a short term rise in the long term interest rates in the US. Granziera & Kozicki (2012) attest that a simple Lucas tree model with extrapolative expectations gives a good estimation of the US housing market from 2000 until 2007 and the subsequent crisis. Granziera & Kozicki (2012) also explain a rational bubble where agents are fully aware of the real asset price, but are still willing to pay more than this amount. This can happen when the expectation of the future house prices is high enough to satisfy the agent's rate of return.

Gelain & Lansing (2014) document in their study that a standard Lucas type asset pricing model significantly under-predicts the volatility under fully rational expectations of the US price to rent ratio. However, it also demonstrates that the model nearly matches the volatility level of the price to rent ratio if near rational agents continuously update their data, using data from the last 4 years.

2.3. Price to rent ratio

The price to rent model is based on the price to earnings model which is often used within finance to evaluate stock prices. The model is the simplest form of relationship between the stock price and the earnings per share, but it gives a good indication of what an investor is willing to pay per unit of earnings. A higher ratio gives a higher expectation towards future earnings. The model was developed by Gordon & Shapiro (1956) and advanced later on by Miller and Modigliani.

Rent is an alternative cost of owning: if renting costs are very low, home owners might prefer to rent instead of owning their home. The intuition behind this is that if the price to rent ratio remains high for a period of time, there will be an expectation of higher demand for renting, which should also drive the rental prices

up. This makes the price to rent ratio constantly converging back to its mean (Himmelberg, Mayer, & Sinai, 2005), (McCarthy & Peach, 2004)).

There are numerous studies that try to estimate the ratio between price and rent through time: Finicelli (2007), Gallin (2008), Ayuso & Restoy (2003), Davis, Martin, & Lehnert (2008) and more. The theory implies that a high ratio above the normal gives a signal of an overpriced market which may indicate a bubble.

2.4. Price to rent ratio on the Norwegian market

Ola Grytten's (2009) study is among one of the few performed on the price to rent ratio on the Norwegian market. His results show that housing was three times more expensive in 2007 than it was in 1993, and that this increase had augmented twice as much as housing in the USA did during 1993-2006. These results are backed up by other studies, mostly master theses such as Bottolfs (2010), Baardsen (2009), Le (2012) and Eivind (2008).

On the other hand, studies show that several other countries have a higher price to rent ratio than Norway. Norway does show historically high values of the price to rent ratio, but compared to other nations it might not be as substantial.

3. Research Hypotheses and Methodology

3.1. Hypotheses

The main objective of this thesis is to create an analysis of the Norwegian housing market. We are going to use the models presented in Granziera & Kozicki (2012) as they explained the housing market and crisis in the American market during the years 2000-2009.

H1: Do the extrapolative expectations account for the development of the price to rent ratio in the housing market?

We believe that the Norwegian market does not differ significantly from the American one - hence we want to implement this theory. Many studies such as Glaeser, Gyourko, & Saks (2005) and Bayoumi (1993) use low real rates, financial deregulation and low housing supply as important factors to determine the growth of house prices. Granziera & Kozicki (2012) state that they get

surprisingly good results even though they do not factor in for these variables. Hence, we want to exclude those variables and focus on the price to rent and extrapolative expectations, which are estimated based on the past and current values of the housing market.

The extrapolative expectations are a function based on the previous price to rent ratio, which is explained more thoroughly in chapter 3.2. Granziera & Kozicki (2012) found that the extrapolative expectations in the American market were irrational and noticed a very optimistic behavior. This resulted in an increase in prices that were based on irrational expectations. Further investigation showed that housing prices were superseding the predictions of the fundamental factors. As mentioned earlier we expect the housing market in Oslo to follow the same pattern as the American one, and considering Norwegians' positive view of the economic future we will be expecting similar results to that of Granziera & Kozicki (2012).

On the other side, there are a lot of different factors affecting the house prices. Larsen & Sommervoll (2003) give a fair overview of the main variables that explain the housing prices. Even though the model explained in Granziera & Kozicki (2012) gives good results on the American market, we believe it is very important to also include the macro-economic factors. Thus, by using the previous research in the field, our additional research question is to test how the determinants of housing prices and the extrapolative expectations are influencing the price to rent ratio.

3.2. Methodology

To create our model, we will be replicating the Granziera & Kozicki (2012) method for the Oslo market. First of all, it is important to state that we treat the houses traded on the real estate market as liquid financial assets that give a stream of dividends to the owner, more precisely the rent, similarly to a stock. The model presented in Granziera & Kozicki (2012) uses the Lucas Tree Model (1978). This is an endowment economy model, where the agent chooses how much to consume and how much equity to retain in order to maximize his expected utility. Granziera & Kozicki (2012) presented three different models, but for our analysis only two of them are relevant: the fundamental solution and the extrapolative

solution. The fundamental solution is showed in equation (1) and computes an estimated methodical solution for the fundamental price to rent ratio in the Oslo housing market. This solution takes basis in essential parameters of the economy, such as risk aversion, discount factor and mean growth rate of dividends.

$$y_t^f = \frac{p_t}{d_t} = \exp(a_0 + a_1 \rho(x_t - \bar{x}) + \frac{1}{2} a_1^2 \sigma_\varepsilon^2) \quad (1)$$

where ρ is the autocorrelation of rents growth rate¹, \bar{x} is the mean growth rate of rents, σ_ε are the standard errors of the rents growth process, α is the risk aversion level and β is the discount factor, and a_1 and a_0 are defined as follows:

$$a_1 = \frac{1 - \alpha}{1 - \rho \beta \exp[(1 - \alpha)\bar{x} + \frac{1}{2} a_1^2 \sigma_\varepsilon^2]} \quad a_0 = \log \left[\frac{\beta \exp((1 - \alpha)\bar{x})}{1 - \beta \exp[(1 - \alpha)\bar{x} + \frac{1}{2} a_1^2 \sigma_\varepsilon^2]} \right].$$

We need to choose the risk aversion level α and the discount factor β . These two variables are very important in forming both a_1 and a_0 , which will have a significant impact on forming the fundamental model showed in equation (1).

Moreover, when analyzing housing prices, extrapolative expectations have been an important factor, Stiglitz (1990) saying that agents form their behavior based on past realizations in the market. Granziera & Kozicki (2012) also define extrapolative expectations as the agents' anticipations based on what has happened in the past. To complete our analysis, we will also use Granziera & Kozicki (2012)'s extrapolative expectations model for the price to rent ratio (see equation (2)), defined as follows:

$$y_t^{ee} = E_t[z_{t+1}] = (y_{t-1}^{ee} + 1)\beta H \exp((1 - \alpha)x_{t-1}) \quad (2)$$

This extrapolative expectation model is derived from the price to rent equation given in Granziera & Kozicki (2012) (equation (3)):

$$y_t = \beta \exp((1 - \alpha)x_t)(\hat{E}_t y_{t+1} + 1) \quad (3)$$

Where:

$$\hat{E}_t[y_{t+1}] = H z_{t-1} \quad H > 0$$

¹ The growth rate of rents are defined as: $x_t = \log(d_t/d_{t-1})$.

The new variable H is a positive extrapolative coefficient which is the weight an agent puts on previous observations to obtain the forecasted variable.

The β was derived to match our real interest rate of 4.350% while for α and H we chose the same values as presented in Granziera & Kozicki (2012) for both extrapolative expectations (A) and (B). These values are showed in Table 1 in chapter 5.1.

3.2.1. Vector Error Correction Model

According to Sims (1980) Vector autoregression (VAR) is a method used by macroeconomists to characterize the joint dynamic behavior of a group of variables without requiring strict assumptions to identify underlying structural parameters. Vector Error Correction Model (VECM) is an extension of VAR which is used when the time series data exhibit co-integration between variables. Moreover, the VECM treats non-stationary variables as stationary by first differentiating. It hereby corrects the disequilibrium in the short run amongst the variables, which reduces the probability of creating an omitted estimation error. In a VECM model where x and y are co-integrated, there will exist a unique α_0 and α_1 so that $u_t = -\alpha_0 - \alpha_1 x_t$ is $I(0)$ (integrated at the same order). If we address this in the single-equation model where we think of y as our dependent variable and x as an exogenous regressor, the error correction equation will be:

$$\Delta y_t = \beta_0 + \beta_1 \Delta x_t + \lambda u_{t-1} + \varepsilon_t$$

The VECM develops this single equation error correction model to make sure x and y evolve together through time as in a VAR system. In the case of more co-integrated equations, λ coefficients are the error-correction coefficients, assessing the response of each variable deviation from the long-run relationship. The expected value of λ is less than 0 because if y_{t-1} is greater than its long-run value towards x_{t-1} then the error-correction term would be positive which results into a constant to a downward movement of y in the period (Sims, 1980).

In our set of variables we notice that we have a strong presence of non-stationarity and by differencing the variables themselves in a VECM model might not be enough to make them stationary. Thus, we will use a traditional method to detrend our data, through the Hodrick-Prescott (HP) technique, which uses a filter to

extract the long-run component of a series. Moreover, we noticed that we obtained better results when we extracted natural logarithm of price to rent and extrapolative expectations and we seasonally adjusted (SA) for the variables salary, unemployment and interest. After these corrections have been made, we applied the HP filter, which gave us cycled variables. We tested the de-trended variables for stationarity by using the unit root tests. The results indicated that, at level, all of the cyclical series obtained are stationary. Therefore, we applied the VECM model on the following equation:

$$\text{Log Price to Rent}_{i,t} = \alpha + \beta_1 \text{SA Salary}_{i,t} + \beta_2 \text{Log Extrapolative Expectations}_{i,t} + \beta_3 \text{SA Unemployment Rate}_{i,t} + \beta_4 \text{SA Real Interest Rates}_{i,t} + \beta_5 \text{Population}_{i,t} + \varepsilon_{i,t}$$

3.2.2. Process of the VECM model

When running our VECM model we will need to check unit roots by using the Augmented Dickey-Fuller test. We will make sure that they are integrated of order 1. This will determine if our data is stationary or not at the 1st difference level in the VECM model. Further we have to control for cointegrated variables; this will be done using the Johansen Co-integration Test. Thereafter, we will need to run a test regarding the right amount of lags, conducted through a Lag Order Selection Criteria. After running our model we will test its reliability by running the heteroscedasticity, autocorrelation and normality tests. We will do this by performing a Breusch-Pagan-Godfrey test, a Breusch-Godfrey test and a Jarque-Bera normality test, respectively.

Furthermore, to get a better understanding of our results we will run a Granger causality test, an IRF (Impulse Response Function) and a variance decomposition.

The Granger causality test allows us to see how one variable might affect another variable. However, the results of the test only suggest that there might be a short-term relationship between the variables, as there might be a third variable having an impact on both initial variables.

The IRF gives information about the dynamic reaction of price to rent to one standard deviation shock in each variable. This will be done through the Cholesky

model and will help get a better understanding in which direction and by how much the variables impact our dependent variable, price to rent.

The variance decomposition will help explain to which extent each variable impacts the other variables in the autoregression function. This will show how the exogenous shocks explain the change of variance from one variable to another. Moreover, it will also help sort out the order we are testing the independent variables against the dependent one.

4. Sample and Data

4.1. Data Description

In order to answer our hypotheses, we collected the data from the Norwegian Statistical Bureau (SSB), Norwegian Central Bank (NB), Norwegian Labor and Welfare administration (NAV) and Bloomberg.

The data is collected quarterly, from 1992 until 2015. Some of the data was also available previous to 1992, however for the most of it we could only find data starting in 1992. Hence, we decided to narrow our research for the 1992-2015 period.

For our study we used housing prices, rent prices and population for the Oslo area collected from the SSB's website. Quarterly data starting in 1992 was available for the Oslo housing prices. The data was index based, where the value 100 was the equivalent to the housing prices of the second quarter in 1998. Thus, we decided to transform the data so that the value 100 corresponded to the housing prices of the first quarter in 1992, but also to be consistent with the rental index. We also decided to transform the data to absolute values, since we had the average housing prices in Oslo for 2015.

As for population only yearly data was available on the SSB website, while for rental prices only a yearly market survey which collects data on the different rents tenants pay in Norway was accessible. Thus, after being in contact with one of the persons in charge at SSB, we obtained quarterly data for both variables. Since they were index based starting in the second quarter of 1998, we indexed both data starting at 100 in the first quarter of 1992.

We collected quarterly data for real interest rates, consumer price index (CPI) and salary (income) from the NB's website. The real interest rates were used as found, meaning in absolute values. As for the CPI, we transformed the index from its base value of 100 in 1970 to a base value of 100 in the first quarter in 1992. Moreover, since the salary is only reported once a year, we downloaded annually data and assumed that the growth rate was constant throughout the year to be able to create the index based quarterly data. Same as the CPI, the salary was index based starting in 1970 and we transformed it to start in 1992.

As for the unemployment rates, we collected the data from NAV. However, since they do not have a statistical database, we obtained quarterly data in absolute values after being in contact with them.

We downloaded the data for the stock prices and dividends from the Bloomberg terminal. The data was also index based and we transformed it in order to be consistent with our previous data.

4.2. Variable Description

In order to check our hypothesis, we will test whether the *Extrapolative Expectations* have an effect on the *Price to Rent ratio*. In addition, we will also test the effect of macroeconomic factors, such as *Salary*, *Unemployment Rate*, *Real Interest Rates* and *Population*, used as control variables, on the *Price to Rent ratio*, our *dependent variable*.

The **Price to Rent ratio** is a measurement often used to check if the housing prices (or rental prices) are too high or too low (Grytten, 2009). The price to rent ratio is computed as the housing prices divided by the rental prices. The rental income reflects how much an investor earns by owning a house, similar to a dividend. Previous literature states that these two variables should move in the same direction. That is because an investor has two options when it comes to the housing market, either to buy or to rent (Kivedal, 2012). If there are long term signs that these variables are diverging from each other, we might have indications of a housing bubble (Grytten, 2009).

Shiller (1990) argued that the **Extrapolative Expectations** is the most important factor in explaining the housing prices. Investors that are used to a well

performing market will base their predictions on past prices, leading to an unwarranted increase in the prices. Granziera & Kozicki (2012) modeled these extrapolative expectations on the American market with surprisingly good results, supporting Shiller (1990)'s argument of extrapolative expectations being an important factor.

Salary and Unemployment are two other significant factors for investigating the housing prices. The situation on the labor market is noteworthy for the investors regarding their valuation of future income. If we expect higher unemployment in the future, we will also expect lower salaries. Previous research shows how unemployment impacts housing prices and proved that a higher rate of homeowners increases the unemployment (Dietz & Haurin, 2003). Higher unemployment implies lower salaries, something that has been addressed in many studies (Jacobsen & Naug, 2005).

We believe that the **Real Interest Rate** is a central variable because it affects the investor's opportunities to take up a loan to finance the house (Jacobsen & Naug, 2005). The changes in the interest rate will also affect the ability to pay back the loan. In Norway, interest rates are tax-deductible, hence it is profitable for investors to use loans (Sommervoll, 2007). However, most studies concluded that higher interest rates have a negative impact on the housing prices (Grytten, 2009).

Population is also an important factor explaining the housing prices. Higher population will lead to higher demand. The evidence on the American market says that higher population tends to give lower housing prices (Glaeser, Gyourko, & Saks, 2005). The same research also states that a higher population gives a negative impact on the utility for the residents. Although from the Norwegian market the evidence is that higher population tends to give slightly higher housing prices (Fredriksen, 2007).

5. Empirical Results

5.1. Granziera & Kozicki's model applied on Oslo housing market

5.1.1. Descriptive Statistics

Table 1 shows the parameters chosen and calculated for the Granziera & Kozicki (2012) model approach. From the formulas explained in section 3.2 Methodology, we calculated descriptive statistics in a similar way to Granziera & Kozicki (2012). The following variables: $yt = pt/dt$ (price to rent ratio), $\log(yt/yt-1)$ (growth rate of price to rent ratio), rt (net return) and $\log(pt/pt-1)$ (growth rate in house prices) are presented with the statistics in Table 2. This is calculated from the actual and simulated data: mean, standard deviation, skewness, kurtosis and autocorrelation. We also simulated two different types of extrapolative expectations (A) and (B). The two are separated with differences within the risk aversion and the extrapolative coefficient.

Table 1 Parameter definition and values

Parameter	Description	Value	
\bar{x}	Mean growth rate of dividends	0.006	
ρ	Autocorrelation of dividends growth rate	-0.033	
σ_ε	Standard errors of dividends growth process	0.005	
		Extrapolative Expectations A	Extrapolative Expectations B
α	Relative risk aversion	2.500	5.000
β	Discount factor	0.973	0.973
H	Extrapolation parameter	0.999	1.012

Note: The β was derived to match our real interest rate of 4.350% while for α and H we chose the same values as presented in Granziera & Kozicki (2012) for both extrapolative expectations (A) and (B).

We notice that our results are fairly similar to the ones Granziera & Kozicki (2012) obtained. Although our fundamental solution model fails to predict the price to rent ratio, we notice the extrapolative expectations model to give a fairly

accurate description of the actual data. We can see from Table 2 that the fundamental model fails to predict the price to rent ratio, while both extrapolative models (A) and (B) predictions are good. Moreover, the extrapolative models have a smaller standard deviation than the actual data.

Table 2 Descriptive Statistics

	Actual	Fundamental	Simulated data: extrapolative expectations	
			A	B
yt = pt/dt				
<i>mean</i>	16.334	6.390	20.720	19.130
<i>standard deviation</i>	6.069	0.001	5.043	4.112
<i>skewness</i>	-1.173	5.280	0.682	1.624
<i>kurtosis</i>	-0.193	1.715	-1.240	-1.453
<i>autocorrelation</i>	0.996	-0.025	1.000	0.996
log(yt/yt-1)				
<i>mean</i>	0.006	0.000	0.006	0.006
<i>standard deviation</i>	0.014	0.000	0.010	0.013
<i>skewness</i>	0.564	1.674	4.065	1.221
<i>kurtosis</i>	-0.192	-0.259	1.972	0.722
<i>autocorrelation</i>	0.325	-0.464	0.780	0.468
rt				
<i>mean</i>	0.028	0.020	0.026	0.026
<i>standard deviation</i>	0.035	0.001	0.026	0.031
<i>skewness</i>	0.401	64.349	4.569	1.673
<i>kurtosis</i>	0.064	-7.384	2.097	0.970
<i>autocorrelation</i>	0.292	0.520	0.800	0.517
log(pt/pt-1)				
<i>mean</i>	0.009	0.003	0.009	0.009
<i>standard deviation</i>	0.015	0.000	0.010	0.013
<i>skewness</i>	0.440	6.347	3.922	1.154
<i>kurtosis</i>	-0.102	-2.036	1.947	0.702
<i>autocorrelation</i>	0.274	0.225	0.782	0.467

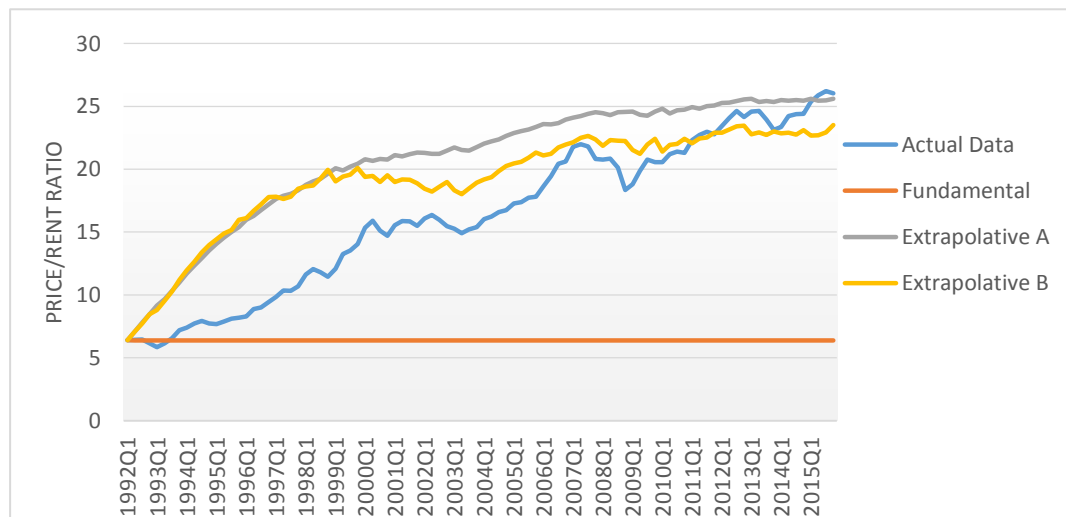
Note: These are the descriptive statistics for the sample from 1992Q1-2015Q4 and the data is simulated as described in chapter 5.1. The variables are defined as follows: **yt = pt/dt** is the price to rent ratio, **log(yt/yt-1)** is the growth rate of price to rent ratio, **rt** is the net return and **log(pt/pt-1)** is the growth rate in house prices. The column “Fundamental” refers to the Fundamental solution model described in section 3.2. The “Extrapolative” refers to the Extrapolative Expectations model described in 3.2. All models are simulated under the calibration from Table 1. Additional parameters are as follows: for the Fundamental solution we use $a_0 = 1.8549$ and $a_1 = -2.330$, for the Extrapolative Expectations model column (A) $H = 0.999$, for column (B) $\alpha = 5$ and $H = 1.012$.

Further, we notice that the skewness of the extrapolative models is of opposite sign, yet the autocorrelation of the models are nearly identical to the autocorrelation of the actual data. This, in consideration with the results shows us that the extrapolative expectations model outperforms the fundamental model in predicting the actual data (Table 2).

It is also important to mention that the extrapolative model (B) predicts the mean of price to rent ratio slightly better than (A), but the standard deviation and skewness have marginally better results for (A). To sum up, the extrapolative expectations (B) is the model that can better mimic data of the price to rent ratio, and it also matches the mean standard deviation of the other variables (Table 2).

Figure 2 shows the evolution of the explained variables in Table 2, presented quarterly from 1992 until 2015. We can see that the results are confirmed, showing that the fundamental model is not a good measure of the price to rent ratio in the Oslo housing market. However, the extrapolative expectations (A) and (B) do give a fairly good description of the evolution of the price to rent ratio.

Figure 2 Price/Rent Ratio Measured Through Different Models



5.1.2. Model performance

To underline the results obtained so far, we follow Granziera & Kozicki (2012) analysis and report the performance data of the model, Root Mean Squared Error (RMSE) and Mean Correct Forecast Direction (MCFD).

RMSE gives information on the accuracy of predicting the series on average. It is also important to mention that RMSE is a quadratic function that penalizes both positive and negative prediction errors in the same way. Granziera & Kozicki (2012) point out that it might be essential to consider a loss function, because financial assets may have positive profits when the forecast sign is correct. The loss function is then defined as follows:

$$MCFD = T^{-1} \sum_{t=1}^T 1(\text{sign}(f_t) \cdot \text{sign}(\hat{f}_t) > 0)$$

where $1(\cdot)$ is an indicator that the model takes a value of one if f_t , the actual variable, and \hat{f}_t , the predicted variable, have an identical sign. It is also important to mention that in contrast to RMSE, the MCFD and also the correlation are almost unaffected by the chosen values for the models. The results of the RMSE, MCFD and the Correlation are shown in Table 3.

Table 3 Model performance

	Fundamental	Extrapolative expectations	
		A	B
RMSE			
<i>Price-to-rent</i>	6.101	2.279	2.754
<i>Net-return</i>	0.035	0.034	0.035
<i>Prices growth rate</i>	0.015	0.015	0.015
MCFD			
<i>Price-to-rent</i>	0.083	0.257	0.233
<i>Net-return</i>	0.259	0.873	0.664
<i>Prices growth rate</i>	0.098	0.295	0.247
Correlation			
<i>Price-to-rent</i>	-0.011	0.928	0.892
<i>Net-return</i>	0.063	-0.164	-0.139
<i>Prices growth rate</i>	0.052	-0.069	-0.046

Note: Root Mean Squared Error (RMSE), Mean Correct Forecast Direction (MCFD) and Correlation between the actual and predicted values are obtained from the models described in chapter 5.1. The column “Fundamental” refers to the Fundamental solution model described in 3.2. The “Extrapolative” refers to the Extrapolative Expectations model described in 3.2. All models are simulated under the calibration from Table 1. Additional parameters are as follows: for the Fundamental solution we use $a_0 = 1.8549$ and $a_1 = -2.330$, for the Extrapolative Expectations model column (A) $H = 0.999$, for column (B) $\alpha = 5$ and $H = 1.012$.

As in the previous analysis, we notice that the fundamental model fails in giving a good prediction results. From the RMSE test we notice that the extrapolative expectations (A) is slightly more accurate than (B). However, we see that net-return and prices growth-rate obtain similar results both through fundamental and extrapolative expectations which is surprising due to the previous bad performance.

MCFD shows how frequently the model predicts in the right direction. Extrapolative expectations (A) predicts the best with a 25.7% in price to rent, 87.3% in the net-return and a 29.5% in the prices growth rate, which is in all cases better than extrapolative expectations (B) and the fundamental model.

Last part of the table summarizes the correlations between the actual data and the predicted models. The fundamental model displays a weak correlation compared to all of the variables. Lastly, the extrapolative expectations model for both parameters (A) and (B) display a high positive correlation towards the price-to-rent ratio, yet low negative correlations with net-return and prices growth rate.

5.1.3. Conclusion of the Granziera & Kozicki model

Conducting an analysis similar to the one done by Granziera & Kozicki (2012), it is important to note that we obtained very similar results both in our descriptive statistics and in our RMSE and MCFD analysis. The model that was solved under fundamental solution performed poorly and would not be a good prediction of the price to rent ratio.

In our descriptive statistics both models of extrapolative expectations (A) and (B) matched the mean, standard deviation, skewness, kurtosis and autocorrelation of the price to rent ratio, while the fundamental model was substantially outperformed. Furthermore, in the MCFD, price to rent ratio shows that the extrapolative expectations (A) give the best trading strategy. We also want to point out that the extrapolative expectation model for both parameters performs remarkably well on the housing market in Oslo considering it does not take into account the traditional macro-economic variables that are known as possible drivers of the housing market.

As mentioned in chapter 3.1, when extrapolative expectations perform much better than the fundamental model we might have irrational expectations. By conducting the approach from Granziera & Kozicki (2012) on the Oslo housing market we found symptoms of irrational expectations in the Oslo housing market. Thus, we can say that parts of the high price level in Oslo today might be fueled by irrational expectations which are also in line with our investigation.

5.2. Additional Analysis: Regression

The analysis presented under section 4 from Granziera & Kozicki (2012) was a prediction of the actual price to rent ratio. With this additional analysis, we want to test if the traditional macro-economic variables can explain the price to rent ratio in a more comprehensive way than the extrapolative expectations model.

The correlation matrix for our regression analysis is shown in Table 4. The correlation between the independent variables is very high, meaning that the likelihood of multicollinearity will become an issue in our analysis. We also expect high levels of autocorrelation as we are modeling some of our variables from appraisal-based data, price to rent and extrapolative expectations (Bond & Hwang, 2005).

In order to test “H1: *Do the extrapolative expectations account for the development of the price to rent ratio in the housing market?*” we ran a vector error correction model. We present our results in the same order they were conducted.

Table 4 Correlation among the model's variables

	<i>Price/Rent</i>	<i>Salary</i>	<i>Extrapolative Expectations</i>	<i>Unemployment</i>	<i>Interest</i>	<i>Population</i>
<i>Price/Rent</i>	1.000					
<i>Salary</i>	0.971	1.000				
<i>Extrapolative Expectations</i>	0.928	0.865	1.000			
<i>Unemployment</i>	-0.677	-0.553	-0.824	1.000		
<i>Interest</i>	-0.696	-0.722	-0.715	0.329	1.000	
<i>Population</i>	0.941	0.988	0.820	-0.509	-0.724	1.000

Notes: The table presents the correlations among the variables of the model and are defined as follows: *Price/Rent* is the ratio of housing prices to rental prices; *Extrapolative Expectations* is calculated based on past realizations to predict future ones, according to Granziera & Kozicki (2012)'s model; *Unemployment*, *Real Interest Rates*, *Salary*, *Population* and were collected from NAV, NB and SSB, respectively.

5.2.1. Diagnostical tests for the VECM model

One of the basic assumptions of VECM is that the variables are stationary under the same difference. Therefore, we tested all our variables through the Augmented Dickey-Fuller test and obtained the following results shown in Table 5. We notice that all of the variables obtain stationary at a 1% significance level, apart from price to rent that obtains it at 5%. However, all variables become stationary at their base level (without using first difference).

Table 5 Unit Root Test

	Augmented Dickey- Fuller Test Statistic
<i>Price/Rent</i>	-3.159 (0.026)**
<i>Salary</i>	-3.748 (0.005)***
<i>Extrapolative Expectations</i>	-5.769 (0.000)***
<i>Unemployment</i>	-3.501 (0.010)***
<i>Interest</i>	-4.856 (0.000)***
<i>Population</i>	-3.726 (0.005)***

Notes: The null hypothesis under the ADF test says that the variable has a unit root. The results show the t-Statistic and the probabilities in brackets below each coefficient estimate. ***, ** and * denote statistical significance at the 1, 5 and 10 percent levels, respectively.

We then continue with the co-integration test. In general, the trace statistic and maximum eigenvalue test yield the same outcome, which is in line with our results. We obtained indications of 4 co-integrating equations from both tests, which conclude that our data is suitable for the VECM model (Table 6).

Table 6 Unrestricted Co-integration Rank Test (Trace and Maximum Eigenvalue)

Number of Cointegrations	Eigenvalue	Trace Statistic	Max Eigen Statistic
<i>None</i>	0.905	367.032 (95.754)*	224.112 (40.078)*
<i>At most 1</i>	0.495	142.920 (69.819)*	64.825 (33.877)*
<i>At most 2</i>	0.365	78.095 (47.856)*	43.142 (27.584)*
<i>At most 3</i>	0.203	34.952 (29.797)*	21.613 (21.132)*
<i>At most 4</i>	0.090	13.340 (15.495)	8.964 (14.265)
<i>At most 5</i>	0.045	4.376 (3.841)*	4.376 (3.841)*

Notes: Both Trace test and Max-eigenvalue test indicate 4 cointegrating equations at the 5 percent level. The critical value appears in brackets below each test coefficient estimate. * denotes rejection of the hypothesis at the 5 percent level.

The next step was to select the number of lags we should use in our model. From the lag selection criteria presented in Table 7, the AIC suggests 8 lags, SC 2 lags and HQ 2 lags. Theory suggests that AIC tends to overestimate the number of lags and SC tends to underestimate. Furthermore, we know that lags tend to devour information within the variables. Thus, we wanted to choose as few lags as possible, but due to autocorrelation issues, we determined 4 lags to be the optimum solution since it removed autocorrelation from our model (Table 7).

Table 7 VECM Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1452.856	NA	10105324.000	33.156	33.325	33.224
1	-865.636	1081.020	36.702	20.628	21.810	21.104
2	-772.494	158.764	10.127	19.329	21.525*	20.214*
3	-726.199	72.599	8.245	19.095	22.305	20.388
4	-694.684	45.124	9.646	19.197	23.420	20.899
5	-627.491	87.046*	5.209*	18.488	23.725	20.598
6	-598.735	33.330	7.094	18.653	24.903	21.171
7	-562.160	37.407	8.674	18.640	25.903	21.566
8	-511.360	45.027	8.441	18.304*	26.580	21.638

Notes: The endogenous variables in the lag selection are Price/Rent, Salary, Extrapolative Expectations, Unemployment, Interest and Population, while the exogenous variable is C (the constant). The sample size is 96, out of which 88 included observations in the test. * indicates the lag order selected by the criterion. The criteria are defined as follows: LR is the sequential modified LR test statistic; FPE is the final prediction error; AIC is the Akaike information criterion; SC is the Schwarz information criterion and HQ is the Hannan-Quinn information criterion. All tests are at 5% level.

5.2.2. VECM Results – Long run causality

The results of the VECM are reported in Table 8 followed up by variance decomposition and impulse response functions. As established from the tests conducted, we ran our VECM with 4 co-integrated equations at 4 lags. This means that we have 4 equations adjusting for the error term in the long-run equilibrium relationship between the variables. The VECM treats all the variables as its own separate regression, hence why we selected our dependent variable price to rent and looked at its coefficients in the long-run relationship. We see that the coefficients from the co-integrated equations are all significant and their values from 1 to 4 are -0.548, 0.000, 0.104 and -0.016, respectively. These results show that the speed of adjustment towards a long-run equilibrium is adjusting -54.8%, 0.0%, 10.4% and -1.5% from the four equations. Hence the disequilibrium within the long-run relationship in the error is corrected each quarter by the respective amounts.

When looking directly at the price to rent as our dependent variable and the remaining variables as our independent, we notice significant results within the following variables: extrapolative expectations at lags 1 and 3 at a 1% and 5% level, salary at lags 1 and 4 both at 5%, interest rate for lags 1 to 3 at 1% while at lag 4 at 10% and lastly, population at 2 lags with 10%. The constant is also significant at a 1% level.

Table 8 VECM Cointegrating Equation and Error Correction Results with Δ Price/Rent as Dependent Variable

Cointegrated Equations					Error Correction Estimates for regression with dependent variable Δ Price/Rent					
	Cointegrated Equation 1	Cointegrated Equation 2	Cointegrated Equation 3	Cointegrated Equation 4	Cointegrated Equations Coefficients	1 Lag	2 Lags	3 Lags	4 Lags	
<i>Price/Rent</i>	1.000	0.000	0.000	0.000	-0.548 (0.089)***	0.340 (0.110)***	0.046 (0.109)	-0.018 (0.102)	0.446 (0.101)***	Δ Price/Rent
<i>Salary</i>	0.000	1.000	0.000	0.000	0.000 (0.000)***	0.000 (0.000)**	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)**	Δ Salary
<i>Extrapolative Expectations</i>	0.000	0.000	1.000	0.000	0.104 (0.022)***	0.568 (0.171)***	0.216 (0.153)	-0.319 (0.132)**	-0.001 (0.005)	ΔExtrapolative Expectations
<i>Unemployment</i>	0.000	0.000	0.000	1.000	-0.016 (0.009)*	0.010 (0.016)	-0.015 (0.018)	0.005 (0.018)	0.007 (0.018)	Δ Unemployment
<i>Interest</i>	-0.009 (0.008)	-1065.811 (393.198)	-0.043 (0.025)	-0.117 (0.096)		-0.014 (0.005)***	-0.014 (0.005)***	-0.013 (0.005)**	0.009 (0.005)*	Δ Interest
<i>Population</i>	0.000 (0.000)	-0.701593 (0.300)	0.000 (0.000)	0.000 (0.000)		0.000 (0.000)	0.000 (0.000)*	0.000 (0.000)	0.000 (0.000)	Δ Population
<i>Constant</i>	0.001	-4.762	-0.057	-0.017	0.009 (0.003)***					
Observations	91	91	91	91	91					
R-squared					0.744					
Adj. R-squared					0.629					

Notes: The dependent variable is *Price/Rent* for Cointegrated Equation 1, *Salary* for Cointegrated Equation 2, *Extrapolative Expectations* for Cointegrated Equation 3 and *Unemployment* for Cointegrated Equation 4. For the Error Correction Estimates, Δ Price/Rent is the dependent variable and all variables are differentiated with first difference (Δ) and the coefficients for cointegrated equations 1,2,3 and 4 are on the first column under the model. All variables are defined in section 4.2 *Variable Description*. Standard errors appear in brackets below each coefficient estimate. ***, ** and * denote statistical significance at the 1, 5 and 10 percent levels, respectively.

Unemployment was the only variable that did not get significant results, which raised some concerns since financial theory tells us that it should have an impact on residential prices. An explanation for this might be that some of the properties of the variables have been lost during the de-trending of the data. Also the fact that VECM automatically takes the first difference of already stationary data at level might make short-term movements impact less on the long-term fluctuations.

Based on the results provided from the VECM, we are positively inclined to believe that extrapolative expectations have a strong impact on the price to rent variable. The model also provides an R^2 of 0.744 and an adjusted R^2 of 0.629 which is good considering it is predicting movements from the real world. Therefore, we are confident with the results obtained and continue our analysis.

5.2.3. VECM – Short run causality

To find the short run causality effects we run a Granger Causality test also known as a Wald test. This allows us to see how variable “x” might affect variable “y”. It is important to state that the presence of causality only suggests that there might be a short-run relationship between the variables, as we do not know if there is a third variable “z” affecting both “x” and “y”. In addition, we believe it is a central test that will show which variables might have an impact on the price to rent ratio and the other way around in the short run. The short term causality results are reported in Table 9.

From Table 9 we notice that several variables have statistical significance. For the purpose of this paper, we are mostly interested in the variables that have causality effects towards price to rent and from price to rent towards other variables. All causality effects going towards price to rent are presented in the first column. Here, we see that extrapolative expectations and interest rate are significant at 1% while salary and population at 5% and 10%, respectively. This proves a short-run causality effect going towards price to rent. Moreover, we notice that price to rent only has a causality effect towards extrapolative expectations and population at 1% and 5% significance level. We find this reasonable as the price level of homes will determine how many people can afford to live in that area and also

Table 9 Vector Error Correction Granger Causality/Block Exogeneity Wald Tests

Dependent Variable	Δ Price/Rent	Δ Salary	Δ Extrapolative Expectations	Δ Unemployment	Δ Interest	Δ Population
<i>ΔPrice/Rent</i>		5.914 (0.206)	17.885 (0.001)***	5.263 (0.261)	1.243 (0.871)	12.122 (0.016)**
<i>ΔSalary</i>	11.310 (0.023)**		5.792 (0.215)	14.020 (0.007)***	4.432 (0.351)	4.495 (0.343)
<i>ΔExtrapolative Expectations</i>	17.881 (0.001)***	1.328 (0.857)		1.345 (0.854)	0.697 (0.952)	4.551 (0.336)
<i>ΔUnemployment</i>	1.113 (0.892)	7.009 (0.135)	9.496 (0.050)**		3.326 (0.505)	3.544 (0.471)
<i>ΔInterest</i>	34.859 (0.000)***	6.991 -0.136	2.612 (0.625)	4.951 (0.292)		4.382 (0.357)
<i>ΔPopulation</i>	8.820 (0.066)*	3.785 (0.436)	4.535 (0.338)	2.292 (0.682)	1.410 (0.842)	
<i>All</i>	73.049 (0.000)***	20.620 (0.420)	38.849 (0.007)***	29.398 (0.080)*	13.929 (0.834)	27.921 (0.111)
Observations	91	91	91	91	91	91

Notes: The dependent variables are Δ Price/Rent, Δ Salary, Δ Extrapolative Expectations, Δ Unemployment, Δ Interest and Δ Population where Δ stands for the first difference. All variables are defined in section 4.2 Variable Description. The degree of freedom for each variable is 4, and for all of them (All) is 20. The results of the test, Chi-sq, are shown in the first row and the probabilities appear in the brackets below them. ***, ** and * denote statistical significance at the 1, 5 and 10 percent levels, respectively.

extrapolative expectations should be influenced by past price values of the housing market.

Further it is in line with financial theory that price to rent is not showing a short-run causality effect towards the other variables, as these variables are often determined from completely other factors than housing prices. The results found in both 5.2.2 and 5.2.3 support our investigation regarding our hypothesis.

5.2.4. Variance Decomposition

As mentioned in the methodology section, the variance decomposition will be beneficial to explain the variation of the fluctuation in our dependent variable. It will show a breakdown of how an exogenous shock may impact the price to rent throughout the independent variables. This will help us determine which variables will have the highest impact towards fluctuations within the price to rent variable.

From the variance decomposition of our dependent variable price to rent we notice that in the short run, from period 1 to 4, it accounts for 100 to 70% of its own variance. This means that a shock to price to rent accounts for 100 to 70% variation of the fluctuation in price to rent. We also notice that in the same period a shock in salary and extrapolative expectations can account for up to 8% and 16%, respectively, while unemployment, interest and population can account for 5%, 1% and 0.5% of the variation in the fluctuation of the price to rent variable (Table 10).

In the long run, from period 10 to 20, we notice a stabilization in the decomposition where the variables, especially interest, salary and extrapolative expectations have increased their impact towards the dependent variable price to rent. At period 20 we see that interest can account for 32% variation of the fluctuation in price to rent, while salary and extrapolative expectations can account for 21% and 12%. Lastly, unemployment and population increase slightly, up to 5% and 2%, respectively.

Table 10 Variance Decomposition

Period	S.E.	Price/Rent	Salary	Extrapolative Expectations	Unemployment	Interest	Population
1	0.019	100.000	0.000	0.000	0.000	0.000	0.000
2	0.026	92.936	0.006	6.747	0.000	0.271	0.040
3	0.030	78.665	1.808	14.991	3.074	1.053	0.408
4	0.032	68.723	8.379	16.054	5.083	1.385	0.376
5	0.037	56.537	18.724	13.977	5.664	4.790	0.308
6	0.044	42.339	25.318	13.907	5.837	12.249	0.349
7	0.049	34.260	25.517	15.138	5.777	19.016	0.291
8	0.051	31.622	24.106	14.706	5.319	23.940	0.307
9	0.054	29.108	22.353	13.822	4.882	29.451	0.384
10	0.056	27.489	20.996	13.580	4.577	32.898	0.461
11	0.056	26.764	20.435	13.798	4.646	33.899	0.458
12	0.057	26.710	20.394	13.677	4.820	33.823	0.576
13	0.057	26.540	20.360	13.586	4.985	33.732	0.796
14	0.057	26.351	20.301	13.502	5.216	33.512	1.119
15	0.057	26.218	20.357	13.337	5.319	33.107	1.662
16	0.058	26.092	20.737	13.109	5.212	32.752	2.097
17	0.058	25.752	21.198	13.023	5.208	32.515	2.304
18	0.059	25.612	21.503	12.907	5.223	32.364	2.392
19	0.059	25.433	21.715	12.826	5.195	32.349	2.482
20	0.059	25.322	21.802	12.748	5.164	32.413	2.551

Notes: The variance decomposition is conducted for 20 periods, where one period represents one quarter.

5.2.5. Impulse Response Functions

We introduce impulse response functions to get a better understanding of what direction and by which amount the independent variables affect our dependent variable, price to rent. We implement a one-standard deviation shock to the independent variables, and as the shock is applied we expect to see that the functions are converging back to zero, else this could be a signal of non-stationarity among the variables. We notice from our functions that they are converging back to zero, which is in line with the Augmented Dickey Fuller test we performed for unit roots; hence, we are confident with the validity of the functions.

In figure 3, the middle left panel shows price to rent's response towards a shock in extrapolative expectations. We notice that it starts from zero and then spikes up to 0.9% before converging slowly towards zero. The intuition behind this is that we see a fairly immediate effect of extrapolative expectations on price to rent that

lasts through several periods before it fades away. This is consistent with our expectations of how extrapolative expectations should affect the housing market.

Figure 3 Impulse Responses Functions



Notes: EE is the *Extrapolative Expectation* variable. We extracted natural logarithm of *Price to rent* and *Extrapolative Expectations* and we seasonally adjusted (SA) for the variables *Salary*, *Unemployment* and *Interest*. After these corrections have been made, we applied the HP filter, which gave us cycled variables (cycle).

In the top panel on the right we see how a shock in salary influences price to rent (Figure 3). Thus, we observe a sharp response to the shock, but interestingly an increase in salary affects the price to rent up to -0.15% before it starts to converge back to zero. This is against our expectations, however, from an economic perspective this might happen because we are analyzing the price to rent ratio and, as clarified earlier in the paper, an increase in rental prices will lower the price to rent ratio, and in equilibrium it should always converge back to its mean value. The intuition would then be when people earn higher salaries, the rental prices

also increase in line or more with housing prices. Hence, the ratio might actually drop from this economic change.

Thirdly, we see in the bottom left panel that interest has a relatively big impact on price to rent. A shock in interest creates a spike in price to rent of up to 0.15% in period 5 and it starts to converge back to zero from period 10. This is also consistent with the results from the variance decomposition where interest was the variable with the highest influential power towards price to rents fluctuations.

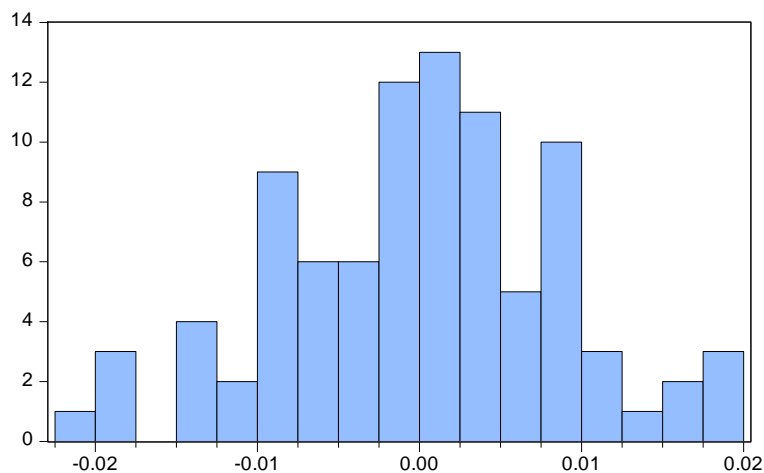
5.2.6. VECM Tests of Heteroscedasticity, Autocorrelation and Normality

To test the validity of our model, we ran tests for heteroscedasticity, autocorrelation and normality. As presented in Table 11, we conclude with a rejection of the null hypothesis and find no presence of heteroscedasticity, thereby our VECM model is homoscedastic.

We ran an autocorrelation test, up to 36 lags, where we found presence of autocorrelation from lag 4 until lag 36. We therefore adjusted our VECM model to 4 lags which eliminated the detection of autocorrelation. Further, we did independent autocorrelation tests at 4 lags for all of the regression equations in the VECM model, which resulted in a rejection of autocorrelation in all variables.

Lastly, we performed the normality test where the null hypothesis was rejected, showing that we do not have normality within our data. Therefore, we did a normality test for each equation within the model identifying the seriousness of the problem. We found normality within all variables apart from extrapolative expectations and unemployment. Although the graph in Figure 4 shows that extrapolative expectations almost follow the bell curve, on some levels it was breaching it. Gelman & Hill (2006) mention that the assumption of the normality is barely important. Therefore, we conclude that the slight presence of non-normality within our model is not a problem.

Figure 4 Normality Test for Extrapolative Expectations



Autocorrelation	Prob
	0.836
	0.964
	0.963
	0.990
	0.997
	0.998
	0.990
	0.995
	0.984
	0.973
	0.981
	0.990
	0.922
	0.915
	0.855
	0.853
	0.888
	0.920
	0.881
	0.893
	0.775
	0.725
	0.758
	0.783
	0.733
	0.779
	0.591
	0.439
	0.364
	0.364
	0.366
	0.396
	0.427
	0.453
	0.327
	0.299

Table 11 Tests

<i>Component</i>	VEC Residual Heteroskedasticity Test	VEC Residual Normality Jarque-Bera Test
1	1120.039 (0.877)	4.639 (0.098)*
2		115.217 (0.000)*
3		0.447 (0.799)
4		1.755 (0.416)
5		148.110 (0.000)*
6		4.763 (0.092)
<i>Joint</i>		274.932 (0.000)*
<i>Observations</i>	91	91

Notes: The Heteroskedasticity test shows no Cross terms and the results, Chi-sq with 1176 degrees of freedom, are shown in the first row and the probability appears in brackets below it. The Normality test shows the Jarque-Bera coefficients and the probabilities in brackets below the coefficients estimates. The degree of freedom for each component is 1 and for all of them (*Joint*) is 6. * denotes the null hypothesis, that is the residuals are multivariate normal. In the Autocorrelation test (the table on the right) probabilities above 10% indicate that autocorrelation is not present among the variables.

Conclusion

Our empirical research objective is to find out if extrapolative expectations account for the development of the price to rent ratio in the Oslo housing market. For this purpose we created a simulated price to rent ratio embedded with extrapolative expectations (y_t^{ee}) along with a fundamental model (y_t^f), based on Granziera & Kozicki's (2012) research paper. We ran these against the actual price to rent ratio (y_t) and obtained very good predictions for the extrapolative expectations under both parameters. We found from the RMSE (Root Mean Squared Error) test that extrapolative expectations (A) was the most accurate to predict the price to rent. From the MCFD (Mean Correct Forecast Direction) test we saw that extrapolative expectations (A) predicted best with a 25.7% accuracy in price to rent, 87.3% in the net-return and a 29.5% in the prices growth rate, which was in total better than the extrapolative expectations (B) and the fundamental model. This informs us that we might have a presence of irrational expectations within the housing market of Oslo, since the extrapolative expectations model is performing much better than the fundamental model.

Furthermore, we ran the extrapolative expectations in a VECM regression with traditional macro-economic variables against the dependent variable price to rent ratio. We began the analysis with a comprehensive look at the non-differentiated data, which gave us a better perspective of our data series. The correlation matrix indicated a very high correlation among the variables, which could be a sign that multicollinearity was an issue. After performing a co-integration test and a lag selection test, we decided to use 4 co-integrated equations adjusting for the errors at 4 lags. The results showed that extrapolative expectations were statistical significant with the price to rent ratio at a 1% and 5% significance level. We also saw through the impulse response functions that indeed extrapolative expectations impacted the price to rent up to 0.9%. We noticed a fairly immediate effect on price to rent that lasted through several periods before it phased out. This is consistent with our expectations of how extrapolative expectations should affect the housing market.

Moreover, results showed that the coefficients for interest, salary and population are statistical significant towards price to rent at a 1%, 5% and 10% level,

respectively. Through the impulse response functions interest and salary had an impact of up to 0.15% and -0.15%, while population had both positive and negative values before converging back towards zero.

In the variance decomposition, we noticed that in the long-run extrapolative expectations had a higher impact than in the short-run on price to rent's variations. We noticed a stabilization of roughly 13% in the long-run, result which is also supported by the impulse response functions. Considering interest and salary had a higher impact than extrapolative expectations in the variation of fluctuations on price to rent and also in the impulse response functions, we can infer that interest is the main influence factor, followed up by salary and extrapolative expectations.

There have not been many studies on this topic, where an extrapolative expectation coefficient has been used as an explanatory factor of the housing prices. Our main contribution in this paper is addressing these expectations on the Oslo housing market where we find significant evidence that they act as a good estimator in predicting the price to rent ratio. To our knowledge, this is the first study to introduce extrapolative expectations on the Norwegian housing market in Oslo. Our results illustrate that extrapolative expectations factor in on the housing market.

This analysis has several implications for both homeowners and investors aiming to get an understanding of price movements within the housing market. We introduce a new economic variable that provides the possibility to further expand the research on the housing market. Additionally, this might create more awareness for homeowners and investors on how much expectations actually factor into the prices.

Our final thoughts are that the model from Granziera & Kozicki (2012) performed very well, informing us of possible irrational prices in the housing market. Backed up with an additional VECM analysis, we found statistical evidence of extrapolative expectations' impact towards housing prices and we confirm our research question "*Do the extrapolative expectations account for the development of the price to rent ratio in the housing market?*" by saying that they account for some of the development of the price to rent ratio in the housing market.

Limitations and further research

In the analysis we have conducted we are using quarterly data with 91 observations. It is a possibility that the VECM model can “devour” the information and provide no significant results. We are also aware that some of the variables’ properties might have been lost by cycling the data along with the seasonal adjustment which might have caused lesser significant results. We also note that we might have omitted some relevant variables for housing prices, considering the complexity of influential factors regarding them. In our model we implemented the factors we considered to contribute the most to housing prices. Another limitation is that homeowners and investors might be, in general, completely rational and do not factor in extrapolative expectations in the price, subconsciously or consciously.

Further research could address extrapolative expectations into a bubble model. As Eyster & Rabin (2010) suggest, individuals are imperfect and homebuyers are naive, given that they rationally calculate the correct price given their belief about the demand and growth in the market. This strengthens the argument of an irrational market subjected to large transaction costs causing market imperfections. These are seen as unhealthy symptoms and may be underlining the probability of a housing market bubble.

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Abstract

In this paper we empirically examine the house price dynamics in the Oslo market. Housing prices in Oslo have been a searing topic in the last couple of years, thus, we believe this will be an important contribution to the literature. First, we will examine how the Price-to-rent ratio together with the extrapolative expectations explain the housing prices Oslo today. In addition, we want to look at all the macro-economic factors and see how well they explain the housing prices. Both of these models we are testing have been successful on other markets, so we want to test both and see which of them yields better results for the market in Oslo. Moreover, we expect to find the most important factors for the housing prices in Oslo, and give an opinion on whether there are some trends that are indicating a housing bubble in Oslo.

1. INTRODUCTION

1.1. Motivation and Objectives

With a steadily increasing housing price over the last years, the predictions regarding the Norwegian housing market, especially for Oslo, gradually become more valid. Fuelled by a low credit cost and a high demand, we see a constantly increasing market. The method introduced by (Granziera & Kozicki, 2012) where they test for not fully rational expectations can explain the recent evolution in price to rent ratios. This was conducted on the American housing market, which we believe was fuelled by unrealistic high expectations. Norway is in a similar state considering it has had a high economic growth ever since they found oil in the 1960's. This has created a highly optimistic generation with high expectations to further growth. Therefore, the aim of our paper is to conduct a similar analysis on the Norwegian market which we believe is central to an enhanced understanding of the current state of the Norwegian housing market in Oslo. We will do this using a Lucas tree model which will explain the sample average of the price to rent ratio. To take into account the volatility we will consider an intrinsic bubble model and two models of extrapolative expectations developed by (Lansing K. J., 2006) and (Lansing K. J., 2010). Even though several studies have been conducted on the Norwegian market and the experts' opinions are divided, up to our knowledge, the models we use in this paper have not been applied on the Norwegian market.

1.2. Research Question

The aim of our paper is to test whether irrational expectations can explain the recent evolution of the price to rent ratio and the house prices in Oslo. We also want to match these expectations with macroeconomic variables to see which yields the best results. This will give an indication of what variables that should be used when conducting an investigation of the Oslo housing prices.

1.3. Contributions

Keeping in mind that the main research of this paper is conducting an analysis on the Norwegian housing market with the aim to get an understanding of how expectations have affected price to rent ratios the last years, our contribution will be to implement the strategy used by (Granziera & Kozicki, 2012) to the Norwegian market. This will show that extrapolative expectations embedded in a simple asset pricing model where rents is the only driving force of house prices can account for the evolution of the actual price to rent and price series.

1.4. Preliminary Thesis Outline

This paper is structured into four parts. Subsequently Introduction, in Chapter 2 we attempt to identify and review the key studies that are relevant to our subject. Therefore, large quantities of theoretical and empirical research related to financial bubbles and asset pricing is organized to make an overview of relevant research towards our field of study. Chapter 3 presents our research hypothesis along with the two regression models. Chapter 4 presents information about our data and variables, also describing the sources and motivation for selecting them.

2. Literature Review

2.1. Introduction to the housing market

In the recent years, much more attention has been paid to the housing market, especially in Oslo and Norway, but also in the rest of the world. The reason for that is mostly because of the big crash in the economy and in the housing markets in several countries under the financial crisis 2007-2009. When it comes to Oslo and Norway, it is important to mention that this market was not hit hard by the

last crisis, and that they have experienced a steady growth in housing prices (Heien & Minge, 2010).

Fluctuations in house prices can have a very strong impact on the real economic activity. Houses or real estates in general are the most important component of a household's wealth, so changes in house prices can affect household's wealth and expenditures (Granziera & Kozicki, 2012). The housing market has a huge effect on the economy, especially through the financial systems; and that is why the major fall and collapse of US housing prices has been looked as the major reason for the economical and financial crisis of 2007-2009 (Granziera & Kozicki, 2012).

2.2. Empirical research regarding the housing market

In recent years, studies regarding dynamic house price models have increased. Most of these studies have been conducted for the USA housing market because of the crisis in 2007-2009. Increased value of houses is an important factor for the real economy. Increased house prices will create a higher level of wealth for households which again will allow households to take on larger amounts of debt, which will increase demand in the housing market as illustrated by (Kiyotaki & Moore, 1997). One common explanation for a boom in the housing market is easily available credit and low real interest rates substantially boosted housing demand and prices (Himmelberg, Mayer, & Sinai, 2005). Abraham & Hendershott (1996) documented that there is a clear correlation with prices and location. They find that there is a substantial difference among inland and costal properties. This makes it clear that also location of the properties factor in as a variable towards the house prices.

Some papers have argued that liquidity limitations can also clarify the excessive sensitivity of house prices in regards to income shocks (Stein, 1995) and (Ortalo & Rady, 1999). They strengthen the theory about liquidity constraints although it is unlikely that they explain why volatility differs across locations.

There is also good reason to believe that the housing market is less efficient than the financial markets. The housing market is dominated by investors trading on their own homes. It is also affected by large transaction costs, tax considerations and so on. Numerous studies on the housing market highlight three main drivers:

macroeconomic drivers, institutional/geographic factors and funding arrangements. This is documented by (Hofmann, 2003), (Herring & Wachter, 1999), (Hilbers, Lei, & Zacho, 2001) although (Shiller R. , 2006) has argued that mass psychology is the most important mechanism driving the prices.

Looking at (Eyster & Rabin, 2010), we assume that individuals are imperfect and that homebuyers are naïve, meaning that they rationally calculate the correct price given their belief about the demand and growth in the market. They forget to factor in the past buyers, such as themselves, that also used prices to strengthen their price assumptions. This results in a case where buyers use an estimate which leads to a misunderstanding of past prices.

The Efficient Market Hypothesis suggests that bubbles cannot exist. In a perfectly rational environment, (Diba & Grossman, 1987) state that a bubble could only exist if the planning horizon of the economic agents is infinite. Stiglitz (1990) argued that if individuals are rational they would foresee the date when the bubble would burst and sell the asset before that, lowering prices. Thus, this price fall would be foreseen, and bubbles would not exist. Hence, there is reason to believe that investors in the housing market are acting irrationally.

An empirical study by (Chow, 1989) states that an asset pricing model with adaptive expectations outperforms one with rational expectations for observed movements in the US stock prices and interest rates. Huh & Lansing (2000) show that a backward looking expectation model captures a better picture of a short term rise in the long term interest rates in the US. Granziera & Kozicki (2012) display that a simple Lucas tree model with backward looking, extrapolative expectations give a good estimation of the US housing market from 2000 until 2007 and the following crisis. Granziera & Kozicki (2012) also explain a rational bubble where agents are fully aware of the real asset price, but are still willing to pay more than this amount. This can happen when the expectation of the future house prices is high enough to satisfy the agent's rate of return.

Gelain & Lansing (2014) document in their study that a standard Lucas type asset pricing model significantly under-predicts the volatility under fully rational expectations of the US price to rent ratio. However, it also demonstrates that the

model nearly matches the volatility level of the price to rent ratio if near rational agents continuously update their data, using data from the last 4 years.

2.3.Price to rent ratio

The Price to rent model is based on the price to earnings model which is often used within finance to evaluate stock prices. The model is the simplest form of relationship between the stock price and the earnings per share, but it gives a good indication of what an investor is willing to pay per unit of earnings. A higher ratio gives a higher expectation towards future earnings. The model was developed by (Gordon & Shapiro, 1956) and worked on later by Miller and Modigliani.

Rent is an alternative cost of owning; if renting costs are very low, home owners might prefer to rent instead of owning their home. The intuition behind this is that if the Price to rent ratio remains high for a period of time, there will be an expectation of higher demand for renting, which should also drive the rental prices up. This makes the price to rent ratio constantly converging back into their mean (Himmelberg, Mayer, & Sinai, 2005), (McCarthy & Peach, 2004)).

There are numerous studies that try to estimate the ratio between price and rent through time (see (Finicelli, 2007), (Gallin, 2008) (Ayuso & Restoy, 2003), (Davis, Martin, & Lehnert, 2008) and more). The theory implies that a high ratio above the normal gives a signal of an overpriced market which may indicate a bubble.

2.4.Price to rent ratio on the Norwegian market

There is quite a limited selection of studies of the Price to rent ratio on the Norwegian market. Ola Grytten (2009) is a highly recognized one, which created a Price to rent analysis of the Norwegian market. His results claim that housing was three times more expensive in 2007 than it was in 1993, and that this increase had augmented twice as much as USA did during the years 1993-2006. These results are backed up by other studies, mostly master theses such as (Bottolfs, 2010) (Baardsen, 2009), (Le, 2012), (Eivind, 2008).

On the other hand studies show that several other countries have a higher Price to rent ratio than Norway. Norway does show historically high values of Price to rent ratio, but compared to other nations it might not be so substantial.

3. Research Hypotheses and Methodology

3.1.Hypotheses

The main objective of this thesis is to create an analysis of the Norwegian housing market. We are going to use the models presented in (Granziera & Kozicki, 2012) as they explained with good results the housing market and crisis in the American market during the years 2000-2009. We believe that the Norwegian market does not differ significantly from the American one - hence we want to implement this theory. Many studies such as (Glaeser, Gyourko, & Saks, 2005) and (Bayoumi, 1993) use low real rates, financial deregulation and low housing supply as important factors to determine the growth of house prices. Granziera & Kozicki (2012) state that they get surprisingly good results even though they do not factor in these variables. Hence, we want to exclude those variables and focus on the price to rent and extrapolative expectations.

On the other side, there are a lot of different factors affecting the house prices. Larsen & Sommervoll (2003) give a fair overview about the main variables that explain the housing prices. Even though the model explained in (Granziera & Kozicki, 2012) gives good results on the American market, we think it is very important to also include the macro-economic factors. Thus, by using the previous research in the field, we can test how both models explain the housing market in Oslo and which variables are most important for the housing prices.

Thus, our hypotheses will be as follow:

H1: Do the extrapolative expectations account for a growth in the house price to rent ratio?

H2: Do the variables low real rates, financial deregulation, housing demand account for a better estimate in the growth of house to rent ratio?

3.2.Methodology

To create our model, we used the price as our *dependent variable*, computed as a first order condition of (Lucas, 1978)'s model, which is a maximization of the expected present value of the agent's lifetime utility

$$p_t = \beta \hat{E}_t \left[\frac{U'(c_{t+1})}{U'(c_t)} (p_{t+1} + d_{t+1}) \right] \quad (1).$$

Based on Lucas's model we will assign values to the parameters and we will compute the price to rent ratio. For the price to rent ratio we will use (Granziera & Kozicki, 2012)'s fundamental solution,

$$y_t^f = \frac{p_t}{d_t} = \exp(a_0 + a_1 \rho (x_t - \bar{x}) + \frac{1}{2} a_1^2 \sigma_\varepsilon^2) \quad (2)$$

where a_1 and a_0 are defined as follows

$$a_1 = \frac{1 - \alpha}{1 - \rho \beta \exp[(1 - \alpha)\bar{x} + \frac{1}{2} a_1^2 \sigma_\varepsilon^2]}$$

$$a_0 = \log \left[\frac{\beta \exp((1 - \alpha)\bar{x})}{1 - \beta \exp[(1 - \alpha)\bar{x} + \frac{1}{2} a_1^2 \sigma_\varepsilon^2]} \right]$$

As the rental income data's frequency is yearly, one year will be considered one period. Thus we will have 45 observations, from 1970 -2014.

To control for other characteristics or factors that might have an influence on the dependent variable, we will use a set of *independent variables* - control variables in order to measure the houses price growth. Based on previous research in the literature, we will use the following control variables for testing hypothesis 1: *Price to Rent* and *Extrapolative Expectations*.

We expect to obtain similar results to (Granziera & Kozicki, 2012), which show that around the unconditional mean the price to rent ratio is stable across time. Even though the model measures the price to dividend ratio, it does not capture the large fluctuations in the data. Therefore (Granziera & Kozicki, 2012) analyzed the housing market based on Lansing's 2006 & 2010 stock market extrapolative models, the expectations arise from past observations.

Based on these models, the extrapolation coefficient is b , which is the weight an agent puts on previous observations. Thus, (Granziera & Kozicki, 2012) write the price to rent ratio as a function of its past values and of the current and past realizations of the dividend growth process.

$$y_t^{nr} = E_t[z_{t+1}] = (y_{t-1}^{nr} + 1)\beta \exp\left(b(1 + \rho)(x_t - \bar{x}) + (1 - \alpha)x_{t-1} + \frac{1}{2}b^2\sigma_\varepsilon^2\right)$$

Where b is derived as:

$$b = \frac{(1 - \rho)m}{1 - \rho k}$$

And k and m are:

$$k = \beta \exp\left((1 - \alpha)\bar{x} + \frac{1}{2}b^2\sigma_\varepsilon^2\right)$$

$$m = (1 - \alpha) + b(1 + \rho)\beta \exp\left((1 - \alpha)\bar{x} + \frac{1}{2}b^2\sigma_\varepsilon^2\right) \quad (3).$$

We will assign values similar to the previous equation.

H1: Do the extrapolative expectations account for a growth in the house price to rent ratio?

$$p_{i,t} = \alpha + \beta_1 \text{Price to Rent}_{i,t} + \beta_2 \text{Extrapolative Expectations}_{i,t} + \varepsilon_{i,t}$$

Furthermore, we would like to test whether there are other factors that can better predict the houses prices. Thus, we will keep the price as our *dependent variable* and for the *control variables*, based on existing literature, (Baffoe-Bonnie, 1998), (Grytten O. , 2009), we will use *Price to Rent, Real Interest Rates, Housing Demand, Deregulation, Unemployment Rate, Salary and Population*.

H2: Do the variables such as real rates, financial deregulation, housing demand account for a better estimate in the growth of house to rent ratio?

$$p_{i,t} = \alpha + \beta_1 \text{Price to Rent}_{i,t} + \beta_2 \text{Real Interest Rates}_{i,t} + \beta_3 \text{Housing Demand}_{i,t} + \beta_4 \text{Unemployment Rate}_{i,t} + \beta_5 \text{Salary}_{i,t} + \beta_6 \text{Population}_{i,t} + \varepsilon_{i,t}$$

4. Sample and Data

4.1. Data Description

In order to answer our hypotheses, we will collect the data from the Norwegian Statistical Bureau (SSB) and Norges Bank. First, we will collect and download the data we need. For our model we will be using the following data: consumer price index (CPI), housing prices in Oslo, number of houses sold in Oslo, rental income in Oslo, real interest rate for Norway, unemployment in Oslo, average salary in Oslo, population of Oslo and the total supply of houses in Oslo. We will be looking at yearly data in our analysis.

The data is collected for the 1970-2014 period. Before 1970, the Norwegian housing market was heavily regulated so an analysis before this date would imply more restrictions, thus affecting our variables. Therefore, the variables in the sample that we chose have great economic explaining power, which lowers the change of having irrelevant variables (β will no longer have the lowest variance, making our results not BLUE).

We will also perform the same analysis on a shorter interval of time, on two sub-samples, one for **1989-1992**, when the Norwegian market housing prices crashed, and one for the last economic and financial crisis, **2007-2009**. Previous research showed that this type of sub-samples can approximately match the volatility of the price-rent ratio in the data if near-rational agents continually update their estimates for the mean, persistence and volatility of fundamental rent growth (Gelain & Lansing, 2014).

In this paper we will conduct two different analyses. The first one will only include the price-to-rent ratio and the extrapolative expectations. In the second analysis we will also include macro-economic data that is important for the fluctuations in housing prices (Larsen & Sommervoll, 2003).

4.1.1 Price-to-Rent

The data will be collected from SSB and Norges Bank web pages, using their standard search page. To obtain comparable time series for this dataset, on both housing prices and rental income on level form, we need to construct two different

time series. An approach similar to this was also used in the paper of (Gelain & Lansing, 2014).

In previous research on the Norwegian housing market, (Grytten O. , 2009) derives the price component from the real estate index published by SSB. For the rental part he uses the historical rental indexes available on SSB and Norges Bank.

Our data will be based on housing prices given by the SSB for the Oslo and Bærum region (Sentralbyrå S. , 2016). We will also use the housing price index from Norges Bank which is delivered by the Norwegian Real Estate Association (NEF) and it accounts for the time period of 1819-2016. Regarding the data on rental prices we will use data provided by SSB for the region Oslo and Bærum (Sentralbyrå S. , 2016).

We will analyze the ratio between housing prices and the rental price (the Price-to-rent ratio) in order to test whether there may exist a bubble in the housing market in Oslo, something that has been studied in other markets; see (Himmelberg, Mayer, & Sinai, 2005). This is one of the oldest models used for pricing stocks, introduced by (Gordon & Shapiro, 1956).

Agents of the housing market are faced with two choices to rent or to buy. This introduces the assumption that housing prices move together with the rental price. As agents will be interested in the difference between the two prices, the demand for the alternatives will always adjust back to the logical value of the fundamental price (Kivedal, 2012). Thus, the price-to rent ratio is an important variable in our analysis, as (Granziera & Kozicki, 2012) showed with accurate results on the American market, we will do the same on the housing market in Oslo

4.1.2 Psychology

A housing bubble can be driven by two factors rational or irrational psychological behavior (Kivedal, 2012). Thus, behavioral psychology is important to factor in (Case & Shiller, 1988). Complete rational expectations tend to underestimate the volatility, and (Granziera & Kozicki, 2012) prove this along with stating that irrational expectations estimate the volatility more accurately.

We use the approach introduced by (Lansing K. , 2009), and assume that investors form expectations in an extrapolative way, meaning their expectations are based on past performance of the variable (Granziera & Kozicki, 2012). Moreover, agents that are used to the well-performing markets, will assume that the market will follow the same trend. Thus, they will behave optimistically, which will lead them to pay a higher price for the property. This effect is relevant regarding the Norwegian market, because it has shown a positive trend since the discovery of oil in the 1960s. This could lead to the assumption that the last generations of Norwegian agents have become overly optimistic. The psychological factor is already accounted for in the data, as the prices for buying or renting a house reflect the optimistic trend.

4.1.3 Macro-economic factors

Granziera & Kozicki (2012) showed that it is possible to model the housing market without accounting for macro-economic factors. Inspired by this research we will implement their research on the Oslo market and test it along with macro-economic factors that other studies claim are important factors (Larsen & Sommervoll, 2003), (Baffoe-Bonnie, 1998).

The macro-economic factors will be real-interest rate, unemployment rate, average salary, population and housing demand. Our data for real-interest rates will be extracted from Norges Bank (Norges Bank, 2016). We will use the average unemployment rate for Oslo in our analysis, and we will collect our data from SSB (Sentralbyrå S. , 2016). The data for average salary will be based on the statistics and data from SSB (Sentralbyrå S. , 2016). This statistic is on the national level, but it will be important to adjust it compared to the CPI index so we get the average salary in Oslo. For our population data we will only use the official statistic from SSB (Sentralbyrå S. , 2016). We will focus on the population of Oslo and Bærum municipalities. For housing demand we will be looking at the number of houses that were for sale that specific from SSB (Sentralbyrå S. , 2016).

4.2.Variable Description

To test our hypotheses, we will use time-series analysis and regression, to see if there is a pattern between the independent variables and the dependent variable, housing prices. Thus, we will use the price as our *dependent variable* for both hypotheses, *Price to Rent* and *Extrapolative Expectations* as control variables for H1 and *Price to Rent, Real Interest Rates, Housing Demand, Unemployment Rate, Salary* and *Population* as control variables for H2.

This has been done both for the American and Norwegian market (Larsen & Sommervoll, 2003), (Baffoe-Bonnie, 1998), and we would like to test which of our hypotheses, either the extrapolative expectations (H_1) or factors that influence the house price changes (H_2), can better predict the prices.

4.2.1 Control variables

Focusing on the set of **independent variables**, for hypothesis 1 we use extrapolative expectations. We will use the Price-to-Rent ratio and extrapolative expectations to test how well they describe the housing prices in Oslo.

The **Price-to-Rent ratio** is a measurement often used to check if the housing prices (or rental prices) are too high or too low (Grytten O. , 2009). The Price-to-Rent ratio is computed as the housing prices divided by the rental prices. The rental income reflects how much an investor earns by owning a house, like a dividend. Previous literature states that these two variables should move in the same direction. That is because an investor has two options when it comes to the housing market, either to buy or to rent (Kivedal, 2012). If there are long term signs that these variables are diverging from each other, we might have indications of a housing bubble (Grytten O. , 2009).

Shiller (1990) argued that the **Extrapolative Expectations** is the most important factor in explaining the housing prices. Investors that are used to a well performing market will base their predictions of past prices, leading to an unwarranted increase in the prices.

The second hypothesis is to check how important macro-economic factors are affecting the housing price and if this is a better predictor on the Oslo market than hypothesis 1.

We believe that the **Real Interest Rate** is a central variable because it affects the investor's opportunities to take up a loan to finance the house (Jacobsen & Naug, 2005). The changes in the interest rate will also affect the ability to pay back the loan. In Norway, interest rates are tax-deductible, hence its profitable for investors to use loans (Sommervoll, 2007). However, most studies concluded that higher interest rates have a negative impact on the housing prices (Grytten O. , 2009).

Unemployment and **Salary** are two other significant factors for investigating the housing prices. The situation on the labor market is noteworthy for the investors, regarding their valuation of future income. If we expect higher unemployment in the future, we will also expect lower salaries. Previous research shows how unemployment impacts housing prices and proved that a higher rate of homeowners increases the unemployment (Dietz & Haurin, 2003). Higher unemployment implies lower salaries; something that has been addressed in a lot of studies (Jacobsen & Naug, 2005).

Population is an important factor explaining the housing prices. Higher population will lead to higher demand. The evidence on the American market says that higher population tends to give lower housing prices (Glaeser, Gyourko, & Saks, 2005). The same research also states that a higher population gives a negative impact on the utility for the residents. Although from the Norwegian market the evidence is that higher population tends to give slightly higher housing prices (Fredriksen, 2007).

Often, research only focuses on the demand-side when investigating the housing prices, but as stated by (Glaeser, Gyourko, & Saks, 2005) the supply-side is an important factor also. A higher **housing supply** means that more houses will be available on the market, if the demand stays the same, prices will fall. Although previous research shows that a higher supply is often reflected through land, physical structure and government approval (Glaeser, Gyourko, & Saks, 2005). However, it takes time for the market to absorb the new supply and reflect it in the price (Fredriksen, 2007).

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