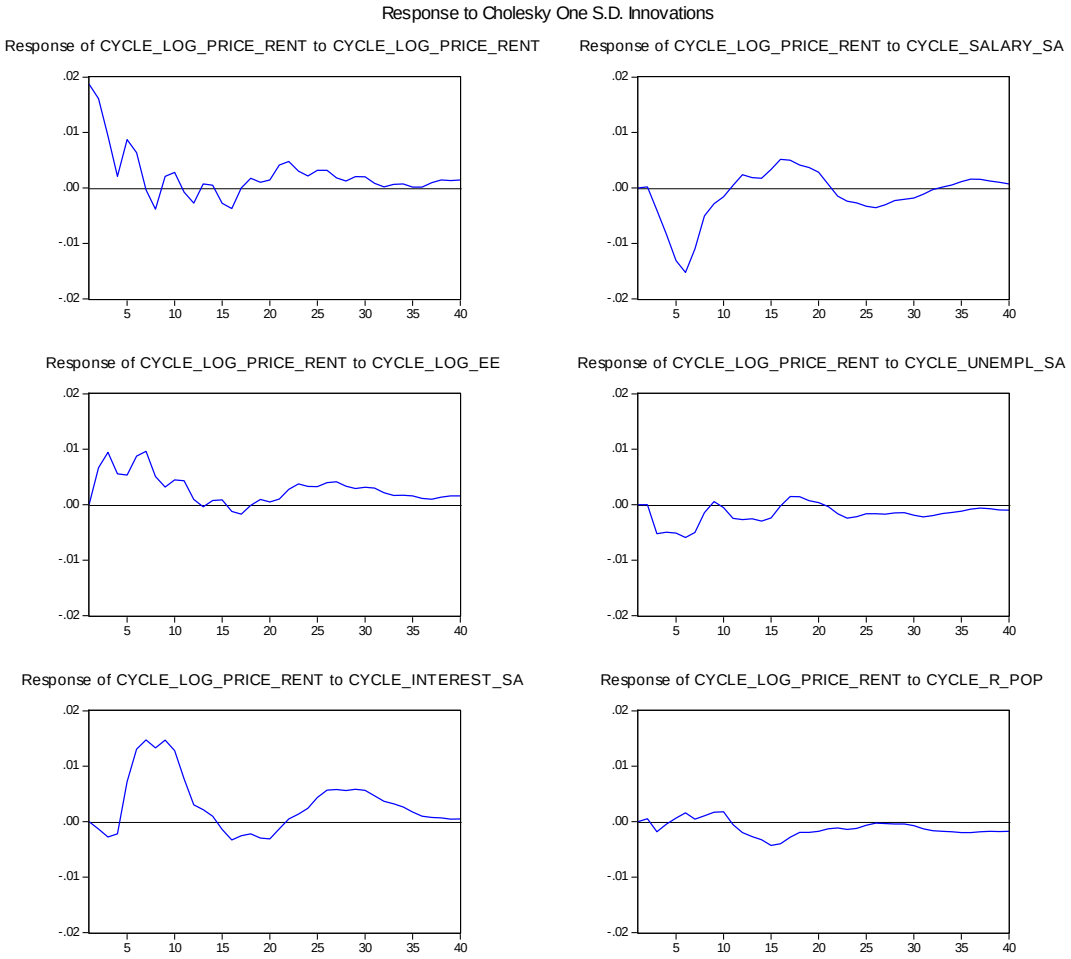
lasts through several periods before it fades away. This is consistent with our expectations of how extrapolative expectations should affect the housing market.

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.

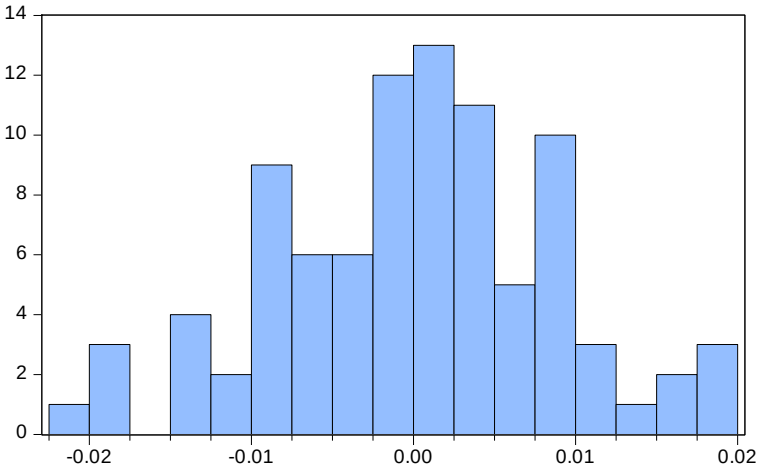
5.2.6. VECM Tests of Heteroscedasticity, Autocorrelation and Normality

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

Component	VEC Residual Heteroskedasticity Test	VEC Residual Normality Jarque-Bera Test
1	1120.039	4.639
	(0.877)	(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)
Joint		274.932
		(0.000)*
Observations	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 autocorellation 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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CONTENTS

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

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

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 stabile 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?

$$\mathbf{p_{i,t} = \alpha + \beta_1\ Price\ to\ Rent_{i,t} + \beta_2\ Extrapolative\ Expectations_{i,t} + \varepsilon_{i,t}}$$

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?

$$\mathbf{p_{i,t} = \alpha + \beta_1\ Price\ to\ Rent_{i,t} + \beta_2\ Real\ Interest\ Rates_{i,t} + \beta_3\ Housing\ Demand_{i,t} + \beta_4\ Unemployment\ Rate_{i,t} + \beta_5\ Salary_{i,t} + \beta_6\ Population_{i,t} + \varepsilon_{i,t}}$$

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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