



Stockholm School of Economics
Master's Thesis in Finance

Historical Drivers of Norwegian House Prices

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Abstract

This Master's Thesis analyzes long- and short-term drivers of Norwegian house prices with data spanning a period of almost 200 years. Data from four major cities is analyzed individually and all together in an aggregated house price index. For this purpose, a single equation error correction model was chosen to capture both the short- and long run dynamics of house price movements. Results indicate that the use of such model is very well suited for this sort of analysis. We find that population, income, and amount of outstanding loans are the most important variables to explain house price movements in the long run and CPI, interest rate, and amount of outstanding loans are most important in the short run.

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1 Introduction

There is not an extensive amount of research made on long term drivers of real estate prices, which is mainly due to the lack of reliable indices reaching more than a few decades back in time. The problems in constructing indices that reaches further back in time are that most often reliable data do not exist. This implies that most studies on real estate value drivers are based on data from a rather short period or less reliable data for a longer time period.

The problem with studies, that do not cover more than a couple of decades, is that the time period often only contains one business cycle with one boom and one bust. When looking at the last decades, investing in real estate might seem as a rather safe investment when compared to other investment alternatives. However, if one looks over other time periods the pattern will be the opposite, with the price development around World War II as an example. This displays the dilemma in determining real estate price drivers, when facing a trade off between sample length and good quality data.

Lately, Norwegian researchers have constructed new indices for most of the possible value drivers of real estate in Norway, presented by the central bank of Norway. The indices reach back as far as 1819, which is very rare for indices with such high quality. The purpose with this thesis is hence to use these indices to try to contribute to the research of long term drivers of real estate prices.

1.1 Structure

This thesis is proceeding as follows. Section 1 includes an introduction followed by background in section 2, including previous research and information about the cities covered in our data sample. In section 3 we introduce our empirical model and discuss dependent variables, potential independent variables and which of these to include in our model. The results and a model simulation are presented in section 4 followed by conclusion in section 5 and suggestions for further research in section 6.

2 Background

In this section we will begin by discussing the relevant research made prior in the field. After this we describe major events and structural changes over our sample period in the four cities we collected data from, including major city enlargements and major socio-economic events. In line with the majority of previous research we have chosen to study the development of house prices using a dynamic model and test for long- and short-term effects separately. Technical details about our choice of model is described more thoroughly in section 3.5.

2.1 Theory and Previous Research

One common, and not very surprising, result in previous research is that demand drives house prices. The demand is primarily driven by income and demographic structure, which hence are the most important value drivers for house prices. Supply, which according to general economic theory plays an equally important role in pricing, does not affect house prices to the same extent. This is since supply of residential property very seldom change rapidly because construction of buildings is time consuming and land is a limited resource. Below we will discuss the most relevant previous research regarding long term drivers for house prices.

In *The Determinants of Urban House Price Fluctuations in Sweden 1968 - 1994*, written in 1998, Katinka Hort made a study of the Swedish housing market between 1968 and 1994. Hort uses a restricted error correction model with panel data from 20 Swedish regions, which is a similar model as the one chosen for this thesis (see section 3.5). In the long run she finds that parameters movements in income, user costs and construction costs have significant impact on real housing prices. This is in line with the common results among researchers in the field, as mentioned above. Her model also includes a negative deterministic trend which she interprets as a proxy for factors not included in the model.

In the long run model Hort gets a very high level of explanation (80 percent). She also concludes that the long-term model adjusts fast to the long-term relationship.

In *A long term Analysis of Regional Housing Markets and Inflation, 2000*, Simon Stevenson examines the relationship between inflation and residential property. Real Estate as a way of hedging towards inflation is a field where an extensive amount of research has been made. The theory has although been questioned during the last decade and Stevenson reexamines this the-

ory in his paper, both on regional and national markets. He aims to extend the current literature by examining the long-term relationship between inflation and the housing market in Great Britain. Stevenson has collected quarterly data from 1968 to 1997 in all standard regions in the UK and uses a conventional OLS regression model to test whether his series are effective hedges against inflation. The OLS tests, which examines actual, expected and unexpected inflation provides little evidence of a relationship between inflation and house pricing, both on commercial and residential property. This is in line with previous research on house prices in the UK. Stevenson finds that his cointegration tests provide strong evidence for that house prices and inflation share a common long-term trend and are cointegrated.

In *Long Run Economic Effects on the Housing Market, 2004*, Piet Eichholtz and Marcel Theebe analyze residential property and rents for almost 450 years between 1550 and 1998 in Amsterdam. Their aim is to understand the long-term drivers of house prices. The main question for their research is to find out whether investing in Real Estate is a way of protecting one's capital from fluctuation in the general economy. Therefore Eichholtz and Theebe also study how the housing market behaves relative to the general economy. This is not a field where a lot of research has been made, mostly due to the lack of long-term indices on house prices. Eichholtz and Theebe have although applied a methodology to construct an index series, which corresponds to the rental housing market. The index is based on historical rental information and is the base for their longitudinal study of the Amsterdam housing market.

Eichholtz and Theebe find that an investor who invests in real estate is exposed to the risks related to the general economy. They further conclude that the housing market tracks the general economy very well, which is in line with the common results in the field that is discussed above. Also during major events, such as wars etc., the house prices adjust to the general economy rather quick. Eichholtz and Theebe conclude that investors cannot hedge themselves towards the general economy by buying residential property.

In *A Simple Error Correction Model of Houses, 1998*, Stephen Malpezzi investigate house pricing in Houston, Los Angeles and Milwaukee in the United States. Malpezzi starts off by studying the equilibrium between house prices and income after which he constructs a simple model to test whether prices have a tendency to revert to some equilibrium ratio of price to income. He continues by studying how supply conditions affect equilibrium prices and the time path of adjustment to equilibrium.

One of Malpezzis major findings, contradictory to previous research, is that the stringency of the regulatory environments was very strong determinant

of the equilibrium ratio. Previous research argue that more stringency of regulations lead to higher housing prices.

In *Booms and Busts in the UK Housing Market, 1997*, John Muellbauer and Anthony Murphy investigate the UK housing market between 1957 and 1994 by using an annual econometric model. Their findings was, as they predicted, that the financial liberations that were made in the UK during the 1980s had a positive impact on house price behavior. They concluded that the shift in house pricing was due to wealth effects, in line with Eichholtz and Theebes findings about the effect of income. Muellbauer and Murphy also concluded that changed consumption function of the financial liberations also affects house prices and that real interest rates and income expectation becomes more important.

2.2 Cities

In this section we will make som brief comments on the development of the house prices in our four cities during our sample period. Major events that has affected the house prices over time in the four cities will be covered. The impact of these events have on our results will also be discussed in section 4.

An important issue to mention about our data is that the indices for the different cities starts at different points in time. This will be discussed in futher detail in section 3.2.

2.2.1 Oslo

Oslo, the capital and the largest city of Norway, has more than 10 percent of the population in Norway. The real house prices for Oslo, as we can see in figure 1, have faced a slightly positive trend over our sample period, with exception for the last decades in the 19th and 20th century when the prices increased fast. During our sample period one can see some changes regarding the development of the population and the construction activity in Oslo. Until 1880 the increase in population and construction activity was seemingly low, but in the 1880s and 1890s one could see a boom in these areas and major parts of the inner city residential buildings were built at this time. This development was the main reason for the fast increase in the house price index during this period.

During the last centuries several enlargement of the city have been made. The largest one was made when the Aker region was incorporated into the

city in 1948. The residential buildings in Oslo which have been built after this has mainly taken place in this region.

Except a few short periods when the population in Oslo has declined, the population in Oslo has, from the beginning of our sample period, increased from 11,000 to more than half a million today. The periods when the population declined took place in the periods 1900-1905 and 1969 -1984. The latter one was primarily due to the fact that many people moved from the inner city to new suburbs.

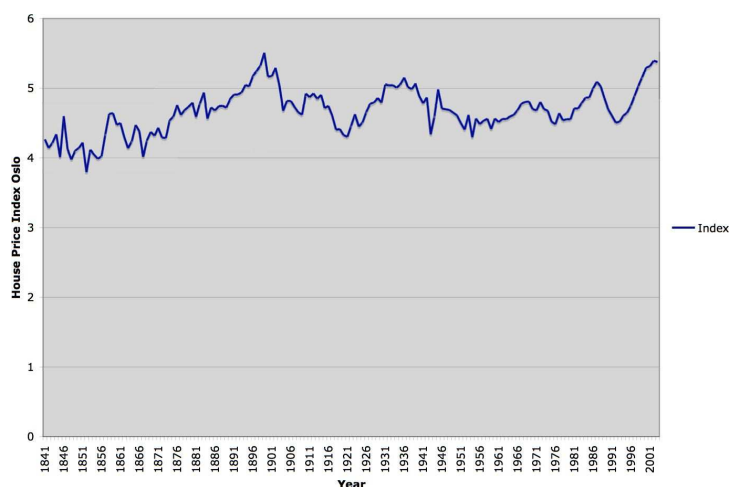


Figure 1: Real house price index development for Oslo in logarithmic scale

2.2.2 Bergen

Bergen is situated on the west coast and is the second largest city in Norway. In figure 2 below one can see that the index for the real house prices in Bergen, as in the case for Oslo, has had a positive trend over time. A similar pattern as for Oslo with increasing prices around the last decades in the 19th and the 20th century can also be seen. However, the sharp increase in the end of the 19th century was not as sharp in Bergen as in Oslo.

Since 1819 the population in Bergen has increased from 16 000 to more than 230 000. The fast increase in the population of Bergen during our sample period is however due mostly to city enlargements. In 1972 the biggest enlargement was made and the population increased from 111 000 to 212 000. Like Oslo, Bergen faced a large increase in the population followed by an increase in the construction activity in the 1880s and 1890s. In the 1970s the inner city population declined as people moved to the suburbs and the overall population in the city leveled out.

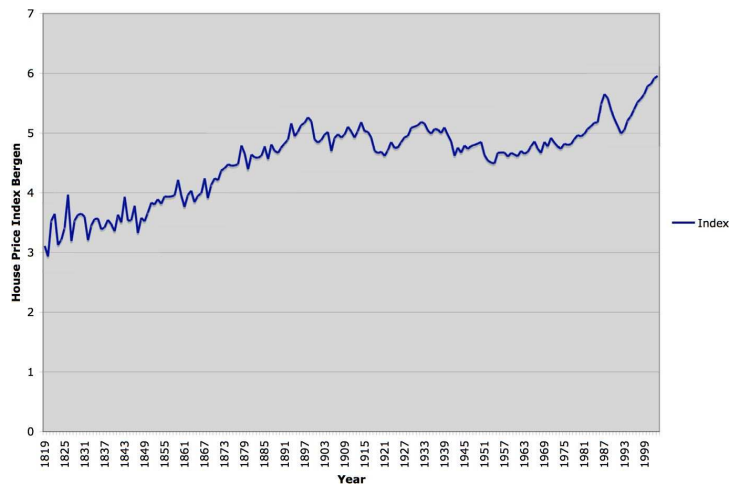


Figure 2: Real house price index development for Bergen in logarithmic scale

2.2.3 Trondheim

The city of Trondheim is the third largest in Norway and has around 150 000 people. As one can see in figure 3 the real house prices in Trondheim have increased in a long-term perspective during our sample period. In the beginning of the index for Trondheim (1897) the prices developed slightly negative until late 1970s when the house prices increased rapidly for a number of years. Then prices decreased fast in the mid 1980s to take off again in a new price boom in the 1990s.

During our sample period the population in Trondheim has continuously increased. As in the case for Bergen and Oslo the population increased after World War II and declined in the 1970s and leveled out in the 1980s. Trondheim enlarged its city boundaries three times in the 19th century and twice in the 20th century. For Trondheim one could see the same pattern with many people moving out in the suburbs after World War II as for Oslo and Bergen.

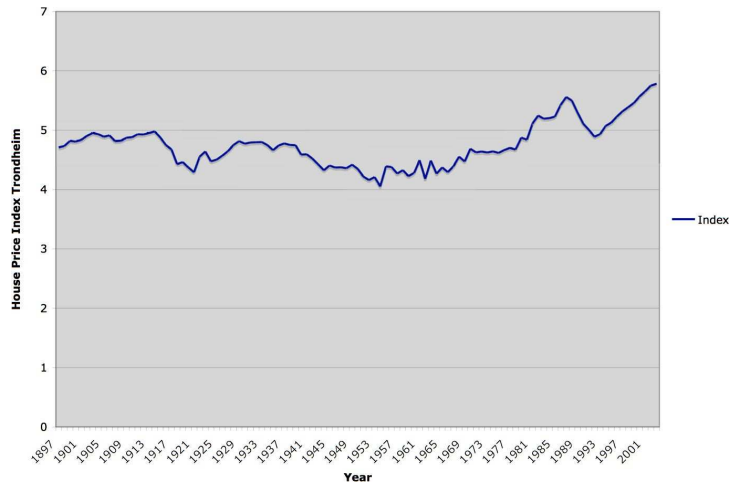


Figure 3: Real house price index development for Trondheim in logarithmic scale

2.2.4 Kristiansand

Kristiansand is located on the south coast and is the fifth largest city in Norway. In figure 4 we see the development of the real house prices in Kristiansand during our time period. Up until the 1960s the house prices hardly moved, although a slightly positive trend can be seen. From the 1960s, when Norway found the oilfields in the Nordic sea and the economy in Norway had a vast upswing, the index has grown rapidly. In the beginning of the 19th century Kristiansand had about 7000 inhabitants and today that figure is about 70 000. As in Bergen, the large increase in the population is due to enlargements of the city boundary. Two major extensions were made in 1921 and 1965, and in particular the latter one increased the population significantly.

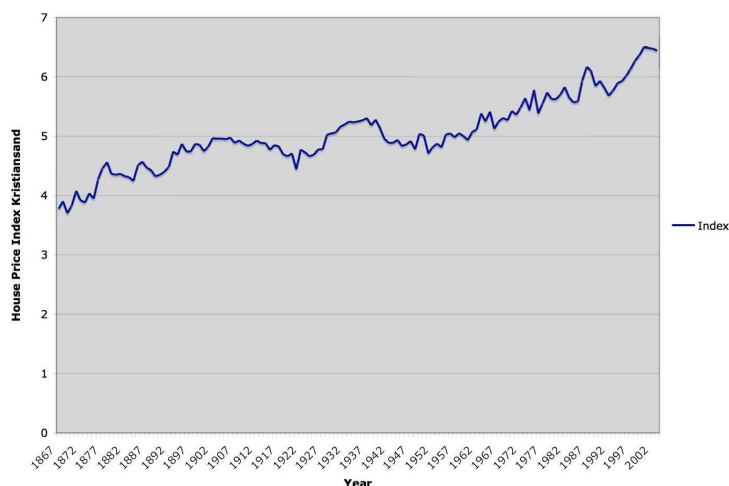


Figure 4: Real house price index development for Kristiansand in logarithmic scale

3 Empirical Model

3.1 Data

In this section we will discuss statistical properties and sources for our gathered data. We begin by presenting our dependent variable and thereafter we will discuss possible independent variables. Then we sum up with a discussion about which variables to include in the model.

3.2 Dependant Variable

Our dependent variable is the house price index constructed and written by Eyvind Eitrheim and Solveig Erlandsen¹. The index contains historical house price indices for the cities Oslo, Bergen, Trondheim and Kristiansand from 1819 to 2003. They have also aggregated the indices to a general index for the four cities. Below we will try to pinpoint the most important aspects of Eitrheims and Erlandsens work. We leave it to the interested reader to investigate their work more thoroughly. In figure 5 below one can see the development of the aggregated index. In general we see increasing house prices during our sample period, with exception for the first half of the 20th century where we have a slightly negative development. In order to obtain real house prices we have subtracted inflation.

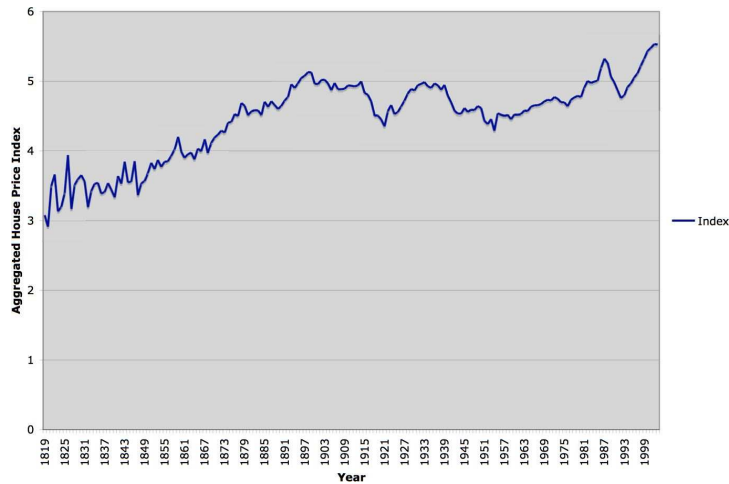


Figure 5: Aggregated real house price index development in logarithmic scale

¹Eitrheim and Erlandsen 2003

Between 1819 and 1985 the house price indices are based on nominal transaction prices of real property, collected from the property registers in the four cities. This was done by using the repeat sales method.² This method suited Eitrheims and Erlandsens research well since the data needed for the repeat sales method easily could be collected in Norway. However, we want to mention that the repeat sales method does not take into consideration how the quality of residential property is, which of course affects house prices. The reason for Eitrheim and Erlandsen to end their research by 1985 is that housing price indices exists after 1985 from previous research. The aggregated index is constructed using a hedonic repeat-sales method³

Eitrheim and Erlandsen have not been able to construct indices for all of the four cities all the way back from 1819. It is only the Bergen index that begins in 1819 and is followed by Oslo (1841), Kristiansand (1867) and Trondheim (1897). The aggregated index consequently only contains of the Bergen index in its first 22 years. For Oslo, Bergen and Trondheim the authors collected two samples, one of real properties with transaction data up to 1935 and another from 1935 to 1989. The sample consists of mainly residential buildings, but also some non-residential buildings. In total Eitrheim and Erlandsen include more than 21 000 transactions in their sample.

²The repeat sales method means that the index is built on repeated transactions of individual houses in the sample.

³The hedonic method is based on detailed data of the house characteristics and the hedonic repeat sales method is hence a combination of the two methods. These two methods have their different pros and cons. An advantage with the repeat sales method is that it does not require as detailed data of house characteristics as the hedonic method does. Although the repeat sales method is not able to use all data, due to the fact that a house must be sold twice during the sample period to be useful for the model.

3.3 Independent Variables

3.3.1 CPI

We see in figure 3.3.1 that until the beginning of the 20th century the CPI index hardly increased at all. After this a positive and relatively steady development followed until Norway in the 1960s found oil in the Nordic sea. This led to a totally new economic situation and the CPI index increased significantly.

CPI data was collected from an article by Ola H Grytten⁴. Grytten has constructed consumer price indices for the period between 1516 and 1871 in Norway. Prior CPI indices did not go back longer than 1871, and after this point in time Grytten simply adds the previous indices to his index. Grytten has collected most of the data from historical archives on wages and prices at the Norwegian School of Economics and Business Administration in Bergen. With this data Grytten managed to increase the validity and reliability for this CPI index for this long period.

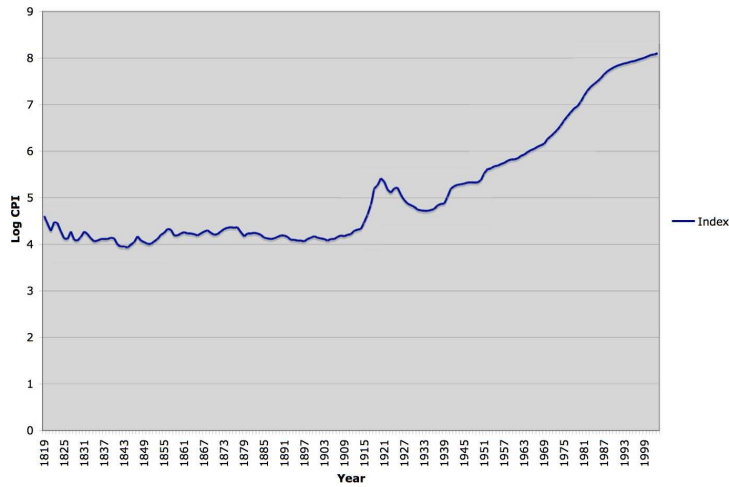


Figure 6: Historical Development of the Consumer Price Index in logarithmic scale

⁴Grytten 2003

3.3.2 Interest Rate

Interest rate is, at least in the short term, an important factor for the development in house prices. The theory behind this statement is that when interest rates are low it is less expensive to borrow and consequently less expensive to own residential property. This will increase the demand, which will increase the prices. The effect is the opposite for high interest rates. We have chosen to use a ten-year government bond as a proxy for our interest rate variable.

Data for the interest rate variable is collected from an article by Jan T. Klovland ⁵ at the central bank of Norway's website. Klovland presents different indices with bond yields. For Klovland's indices the bonds before 1921 only allows for computation of long term maturities for average yields. After this point in time the data cover all maturities along the yield curve. In our chosen government bond index Klovland has derived his bond yield estimates from Norwegian bonds traded on north European stock exchanges. To obtain real interest rates we deduct expected inflation⁶ from our interest rate index.

In figure 7 below we see the development for the interest rate in our sample. As we can see the interest rate has most of the time been seemingly steady between four and six percent during our period. A major shock occurred in the 1870s when the rate under a short period rose up to 15 percent and in the late 1970s and early 1980s the interest rate was as high as almost 14 percent for a couple of years.

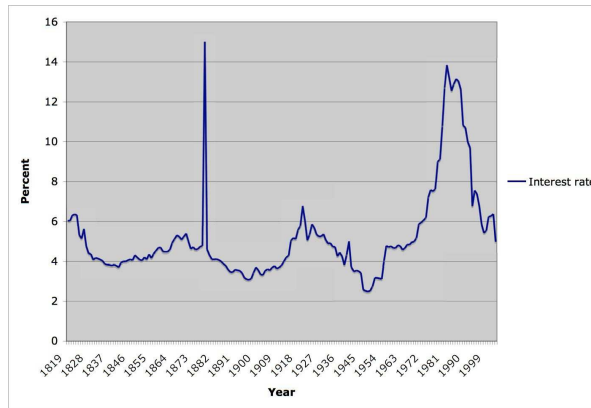


Figure 7: Historical Development of the Interest Rate

⁵Klovland 2003

⁶Expected inflation is assumed to take on the value of the average inflation during the following three years.

3.3.3 Credit

The credit variable represents the total amount of outstanding loans to the general public in Norway. The intuition behind including this variable is that the more outstanding loans there are to potential buyers of residential property, the higher prices the house market will face. We therefore expect a positive relationship between our house price indices and our credit index. Of course, not all money in the outstanding loans is invested in residential property, but one can assume that a large fraction of it is. This makes us believe our lending variable will be an important determinant in our model. The development of our credit variable can be seen in figure 3.3.3.

Eitrheim, Karsten Gerdrup and Jan T. Klovland has written an article where they present data for the credit granted by commercial and savings banks from 1840 to 2003.⁷ Before this date the majority of the credit granted to the private sector came from Norges Bank. In 1840 Norges Bank granted 82 percent of the outstanding credit to the general public and after 1840 that figure decreased significantly when Norges Bank to a larger extent took the role of a more typical central bank.

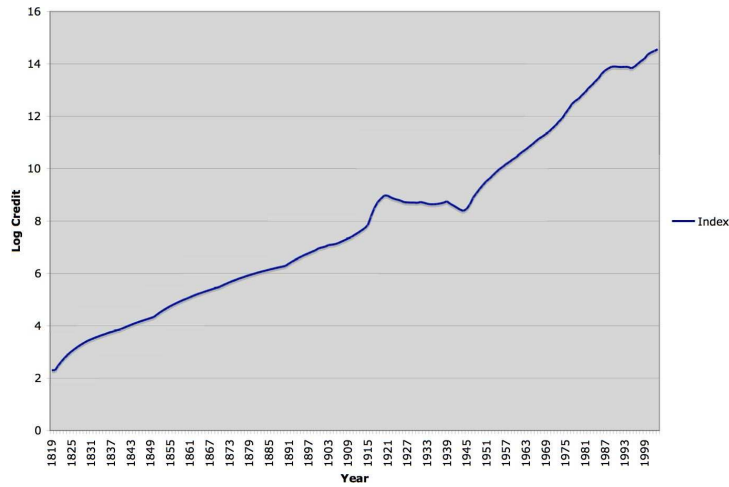


Figure 8: Historical Development of the Credit in logarithmic scale

⁷Eitrheim, Gerdrup and Klovland 2003

3.3.4 Population

The theory behind including population as a variable for the determination of house prices is that a larger population will generate higher house prices. This theory is based on several factors. Firstly, when the population in a city increases the construction of new residential buildings generally takes time, which leads to higher demand and higher prices. This process is constantly going on which makes the demand on residential property higher in a city with increasing population than a city with constant population. Another factor is that when a city is growing it is getting more and more attractive to live in the inner city. This leads to prices rising and the all people will not afford to live there and instead move to the suburbs, which not is the case for small cities where suburbs do not exist to such a large extent.

Our population data has by far been the most complex data source for several reasons. Extensive population data does not exist for such a period back in time for each of our cities. Finally this data was found on the website of the University of Utrecht in the Netherlands, where the Dutch researcher Jan Lahmeyer has published a vast work on population data⁸. However Lahmeyer has only reported data for every tenth year for the cities in our sample. To solve this problem we have interpolated these missing values, which we believe is the method that give us the best estimate of the population for the years of missing data. Finally, for the aggregated index we simply added up our population for the four cities to a total sum.

Another problem when dealing with the population, as we mentioned in section 2.2, is that several city enlargements have been made in the four cities. These have the effect that the populations increase significantly, but the increases do not have any effect on the demand for residential buildings, which in theory will result in that our population index will have a less significant relationship with our house price index. In order to avoid this we have deducted the enlargements in our indices. However, data on the exact size of these enlargements are not available in a couple of cases and therefore our population variable is not totally satisfactory. In figure 9 we can see the development in the population and one can immediately see that the development for Oslo differs from the development in the other cities. As we see, Oslo has from the late 1890s and onwards, with some exceptions, grown faster than the other cities. This is due to the fact that from this period Oslo has to larger extent taken the position as the big economic and commercial centre in Norway.

⁸<http://www.library.uu.nl/wesp/populstat/populframe.html>

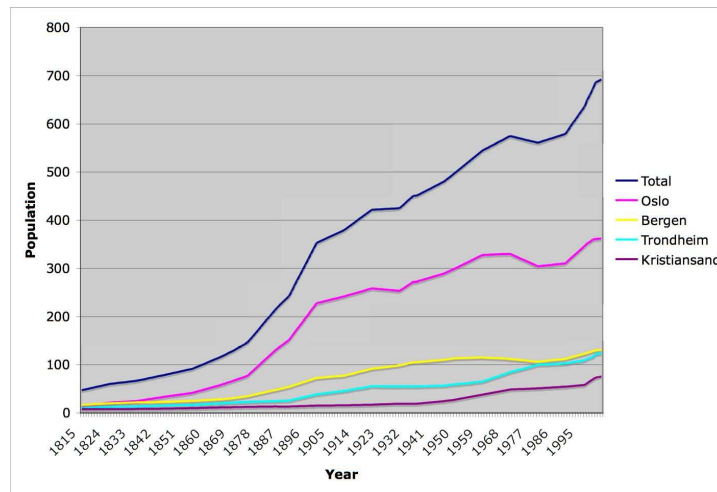


Figure 9: Historical Development of the Population

3.3.5 Income

We have chosen to use the gross domestic product (GDP) to display our income variable. Income is, at least in theory, a very important factor when determining house prices. The theory implies that prices for residential buildings increase when incomes increase.

GDP data was collected from an article by Ola H. Grytten.⁹ When Grytten in 2003 did this research the existing national accounts for Norway only stretched back to 1865, but Grytten has managed to extend this to 1830 with sources from contemporary scholars, Statistics Norway and Professor Ingvar Wedervang's Historical Archive on Wages and Prices, which are kept at the Norwegian School of Economics and Business Administration in Bergen. By benchmarking with other indices and interpolating with annual indicators in important sectors for this time, Grytten has managed to construct GDP figures stretching back this far in time. After 1865 Gryttens index simply is spliced with the existing national accounts.

In figure 3.3.5 we can see the development for GDP per capita during our sample period. Until World War II the development in the GDP was slightly positive and rather steady. During the war the GDP decreased. As we can see the GDP has increased fast after the war, mostly due to the upswing in the economy after the war and the fact that Norway found oil in the Nordic sea in the 1960s.

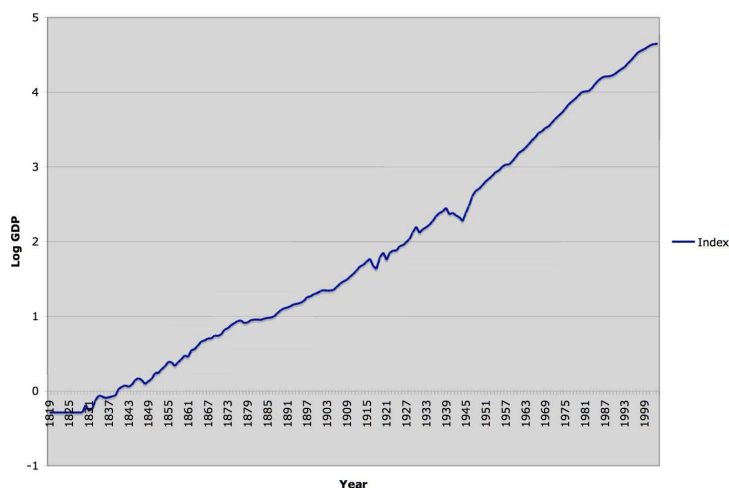


Figure 10: Historical Development of the GDP in logarithmic scale

⁹Grytten 2003

3.3.6 Exchange Rate

Regarding exchange rates we have chosen to use the Norwegian krona (NOK) against the British pound (GBP). We have chosen to use NOK/GBP due to two reasons. Firstly GBP relates good to the NOK and therefore a change in NOK/GBP would display an up- or down swing in the Norwegian economy. The second reason is that the NOK never has been fixed to the GBP or vice versa during our sample period. The intuition behind this theory is that an increase in NOK/GBP would indicate a better economy in Norway, which intuitively will lead to increased house prices. Therefore we believe our house price index and the NOK/GBP will have a significant relationship.

The exchange rates data was collected from an article by Jan T. Klovland.¹⁰ Jan T. Klovland, who also wrote and constructed the data for the interest rate variable, has also constructed the exchange rate data, where he explains different sources and data for exchange rates quoted on the Christiania Stock Exchange since 1819.

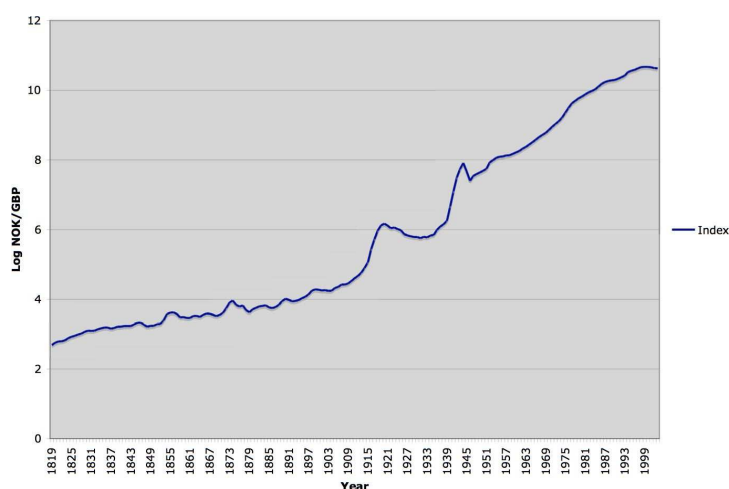


Figure 11: Historical Development of the NOK/GBP in logarithmic scale

¹⁰Klovland 2003

3.3.7 Monetary Base

The theory behind including monetary base in our model is that an increased monetary base will lead to higher house prices. We although assume this variable to develop in line with the CPI, and expect a high correlation between the two variables.

The monetary base consists of all money in circulation plus total deposits at Norges Bank, excluding Treasury deposits. The data for our monetary base variable was collected from an article by Jon P. Holter.¹¹ In figure 3.3.5 we see the development of the monetary base in Norway. Until the end of the 1840s the monetary base did not increase very much, but at this time an expansion of the banking sector took place and the monetary base increased. This can hardly be seen due to the much larger increases in the 20th century. As one can see the monetary base grew rapidly from the 1930s and onward. This was mostly due to that Norway left the gold standard in 1931 followed by dramatic changes in the monetary policy. An appreciation of the exchange rate and a huge monetary expansion lead to that the value of the krone fell to one half of the value against its prior value. A continuation of the new monetary policy and the finding of oil in the Nordic sea have continued this development in the latter part of the 20th century.

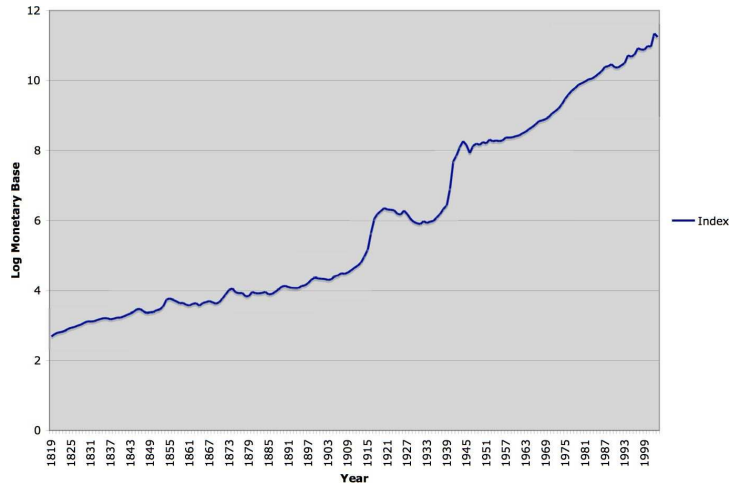


Figure 12: Historical Development of the Monetary Base in logarithmic scale

¹¹Holter 2003

3.4 Variables Chosen

In this part we will discuss which of our previously explained variables we have chosen to use in our forthcoming short- and long-term models.

3.4.1 Long-term Model

For our long-term model we have chosen to use income (GDP), population and credit. Hence we have chosen to leave out monetary base, inflation, exchange rate and the interest rate. The approach behind our chosen variables has been to exclude variables that are varying much within a business cycle, and focus on variables that generate long-term value.

The intuition behind including income is, as previously mentioned, that if income increases there will be more room for investing in residential property which will lead to rising prices. One can also assume that the development of income is strongly correlated to the development of the general economy. This theory is strengthened by Eichholtz and Theebee¹² long run study, covering the development of Amsterdams housing market for almost 450 years, where they conclude that the house market tracks the general economy amazingly well in the long-run.

Regarding population, the theory is rather simple and implies that a larger population will lead to increased demand and thereby higher house prices.

The credit displays the amount of outstanding loans, which one can assume is used for investments in residential property to a large extent. Hence, a larger credit would imply that more money is invested in residential property, which leads to higher house prices. The choice to include credit was to a large extent a choice between the financial variables credit and monetary base which can be assumed to be somewhat correlated. Although, we believe that credit has more explanatory power for house prices since outstanding loans to a larger extent is used to purchase residential property than the monetary base in general.

3.4.2 Short-term Model

The variables in our short term model are not mainly chosen from theory as in the long-term model. The variables included are determined by exclusion of insignificant variables. In our short term model we ended up choosing to include the variables credit, interest rate and inflation.

¹²Eichholtz and Theebee 2004

3.4.3 Testing the Order of Integration for the Selected Series

Augmented Dickey-Fuller tests were performed on the level and first differences of the series that were included in the cointegrating regression. The hypothesis of a unit root was tested against mean stationarity. The null hypothesis of a unit root was not rejected for any of the series on a 10 % level. In some of the tests the presumption of white noise is violated and the tests should therefore in general be interpreted with caution. However, in line with the reasoning of Haldrup and Hylleberg¹³, we will approximate the series as an integrated process because they have proven to contain a strongly autocorrelated component.

¹³Haldrup and Hylleberg, 1991

3.5 Model Background

For the empirical analysis part of this thesis we have chosen a single equation error-correction model. In the long-run it is reasonable to all variables together follow a trend, i.e. the variables themselves are non-stationary but when combined they are in the long run stationary. In such case an error-correction model is well suited, and, as previously mentioned, has been frequently utilized in previous research to capture the dynamics of house prices.

After having concluded that all the series contain one unit root¹⁴, the first step is to estimate the long-run relationship in order to obtain the lagged residuals. Provided that these are mean-stationary they can be used to capture the short-run dynamics of the house prices. If we let $X_{i,t}$ be the explanatory variables, the long-run relationship then looks like:

$$P_t = \alpha + \gamma_i X_{i,t} + \epsilon_t, \quad i = 1..n, \quad t = 1..m, \quad (3.1)$$

where n is the number of independent variables and m is the number of years included in the model. The second step is to estimate the short-term model that represents the variations in house prices:

$$\Delta P_t = \beta_j \Delta X_{j,t} + \beta_{k+1} \cdot (P_{t-1} - \alpha - \gamma_i X_{i,t-1}) + \mu_t, \quad j = 1..k, \quad (3.2)$$

where k is the number of explanatory variables in the short-run model. Contrary to when estimating the long-run relationship, the explanatory variables in (3.2) are selected solely based on significance.

Real house prices are governed by two types of forces. First, the impact effects of new shocks hitting the market implies that real house price movements will depend on current differences in the fundamental determinants of house prices. Second, the impact of a shock is much greater in the short-run. Prices tend to revert to a steady state. Subsequently, the difference between the short term market price and the steady state price should have a negative impact on the next period's price changes.

By including the residual from 3.1 we allow for short-run price development to depend on deviations from the long-run equilibrium. We expect the contribution from the residual term, β_{k+1} , to be negative and thus counteract the short-run overshooting that often occurs following shocks in the

¹⁴by means of ADF tests

explanatory variables. In addition, if demand adjusts slowly to shocks or if supply adjustment takes more than a year, this will turn up as a positive autocorrelation in the short-run equation.

4 Results

Since the long-run model (4.1) is chosen in accordance with theory it will include the same variables for all cities as well as the aggregated index. The only deviation is the population variable which is unique for each city and aggregated for the total index.

The variables chosen in the long-run equation conforms with the theoretical discussions in previous sections and when plugged into equation (3.1), the long-run model is:

$$\log P_{t-1} = \alpha_1 + \gamma_1 \log GDP_{t-1} + \gamma_2 \log CRED_{t-1} + \gamma_3 \log POP_{t-1} + \epsilon_{t-1}. \quad (4.1)$$

City	Total	Oslo	Bergen	Trondheim	Kristiansand
Constant	2.186	4.334	2.227	3.310	5.732
ln(GDP)	0.363	0.575	0.240	0.062 ^a	1.142
ln(Credit)	0.151	-0.025 ^a	0.238	0.312	0.111
ln(Population)^b	0.473	0.227	0.549	0.156 ^a	-0.786
R²	0.899	0.551	0.890	0.572	0.898
Observations	184	164	184	107	137

^aNot significant on a 10 % level

^bPopulation corresponds to the respective cities

Table 1: Unstandardized coefficients for the long-run model

The t-values and their corresponding levels of significance do not play an important role in choosing the long-run equation since the model is determined based on theory. However, it can be added that all but three of the variables in the table above are significant on a five percent level.

Note that the R^2 values for Oslo and Trondheim are significantly lower than those corresponding to the aggregated index and the two other cities. This can be attributed to several plausible facts. The adjustments made for the expansion of Trondheim is somewhat unreliable and house price data only exists after 1897. Oslo has experienced a development quite different from the others, probably due to the city being the nation's capital and financial center in the end of the 19th century, which lead to that Oslo faced a boost in the economy. Had we had any income data segmented for the different

cities the results would have likely been better. We would then have been able to capture the income demographics of the country which naturally plays an important role in this context.

The short-run model is as previously mentioned mostly determined by level of significance in the variables. Thus, the model will pan out differently for each city.

4.1 Aggregated Index

By exclusion of insignificant variables, the short-run model for the total index is quickly down-sized to containing only three differential variables in addition to the lagged residuals attained in the previous step.

	Unstd. Coeff.	t-value	Significance
$\Delta \log \text{ CPI}$	-0.818	-5.886	0.000
$\Delta \log \text{ Credit}$	0.235	2.029	0.044
$\Delta \log \text{ Interest}$	0.390	3.642	0.000
$\epsilon_{Total,t-1}$	-0.367	-5.708	0.000

Table 2: Unstandardized coefficients for the aggregated index in the short-run model. $R^2 = 0.232$. Durbin-Watson test statistic = 1.793 (LL=1.715, UL = 1.803, on a 5% level).

$$\begin{aligned} \Delta \log P_t = & \beta_1 \Delta \log CPI_t + \beta_2 \Delta \log CRED_t + \beta_3 \Delta \log R_t \\ & + \beta_4 \epsilon_{Total,t-1} + \mu_t \end{aligned} \quad (4.2)$$

The results of the short-run dynamics are somewhat puzzling. We initially expected the interest rate to have a negative relation with the house price index but the results clearly suggest the opposite. In order to understand these results it is important to keep in mind that the short-run model only gives the dynamics for short, one year movements. In a one-year perspective this could be reasonable since an interest rate increase could be seen as an indicator for an overheated economy. In the short run, this could mean that people are optimistic about the economy and that they are, for the moment, well off resulting in driving house prices up regardless of the added cost of borrowing money.

As expected, the credit variable sign is positive. With people borrowing more money it is natural to assume that at least a fraction of this goes to

purchasing real estate.

There is a negative relation between inflation and house prices as predicted. Regarding inflation Stevenson examined the relationship between inflation and residential property between 1968 and 1995 in UK. Stevenson found little evidence of a clear relationship between these variables. However it is reasonable to assume that inflation in the short run might be a proxy for the uncertainty in the real estate market, where a higher inflation implies a higher degree of uncertainty.

Even though some of the explanatory variables' relations to the dependant variable are curious the complete model is rather good, as can be seen in figure 13 below. This in-sample simulation of the model is simply:

$$\begin{cases} \hat{P}_1 = P_0 + \Delta\hat{P}_1 \\ \hat{P}_2 = \hat{P}_1 + \Delta\hat{P}_2 \end{cases} \quad (4.3)$$

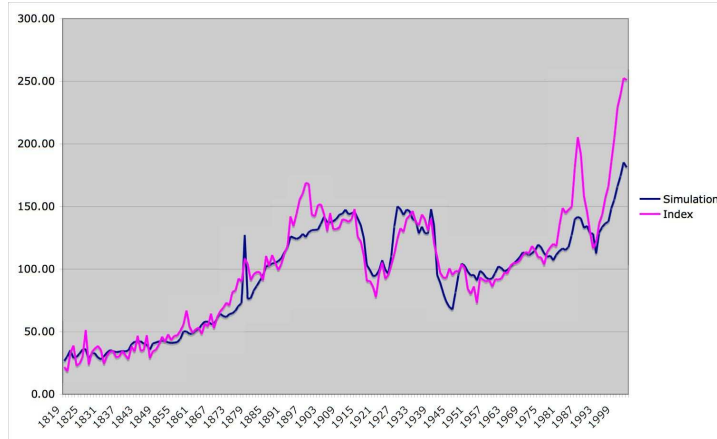


Figure 13: Model simulation for the aggregated index.

The effect of the error correction term is significant as can be seen in figure 14, particularly during the second half of the studied time period.

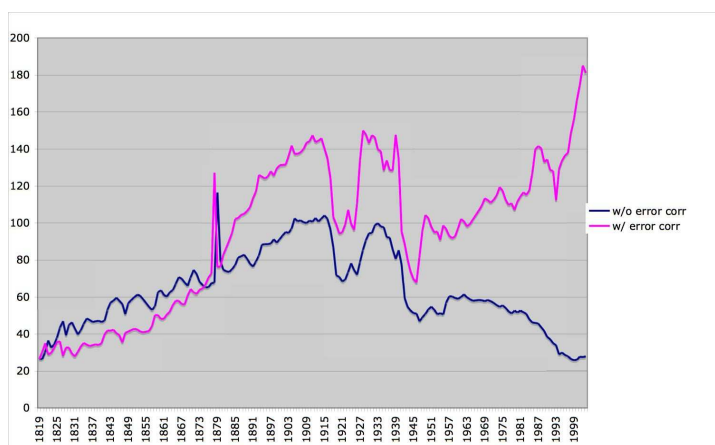


Figure 14: The effect of the error correction term

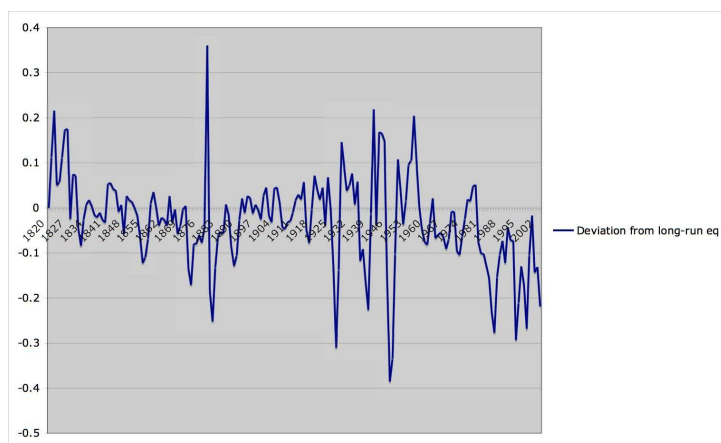


Figure 15: Deviation from long-run equation

4.2 Results for the specific cities

The results on city level is far more unreliable than those of the aggregated index, which is evident from the R^2 values (note, however, that we expect low R^2 value levels since we are dealing with differences). The alterations of city limits that have caused problems are less severe on the aggregated index and it seems as if the errors cancel each other out to a certain extent. Another problem that affects the results for the cities individually is, as mentioned earlier, that most of the data for our explanatory variables not are city specific. Consequently a change occurring in one city affects the results for other cities. The variables used in the short term model are defined by taking the logarithms of the first differences of each variable.

4.2.1 Oslo

After excluding insignificant variables for Oslo we ended up with inflation, amount of outstanding loans (credit) and population as one can see in table 3. In line with theory, the CPI coefficient is negative and the population and credit variables have positive coefficients. Inflation and credit are significant on a five percent level, but the population variable is only significant on a 10 percent level.

	Unstd. Coeff.	t-value	Significance
$\Delta \log \text{CPI}$	-0.777	-4.100	0.000
$\Delta \log \text{Credit}$	0.269	2.064	0.041
$\Delta \log \text{Population}$	0.931	1.781	0.077
$\epsilon_{Oslo,t-1}$	-0.372	-5.986	0.000

Table 3: Unstandardized coefficients for the short-run model for Oslo. $R^2 = 0.201$. Durbin-Watson test statistic = 1.797 (LL=1.695, UL = 1.795, on a 5% level).

$$\begin{aligned} \Delta \log P_t = & \beta_1 \Delta \log CPI_t + \beta_2 \Delta \log CRED_t + \\ & + \beta_3 \Delta \log POP_t + \beta_4 \epsilon_{oslo,t-1} + \mu_t \end{aligned} \quad (4.4)$$

4.2.2 Bergen

For Bergen, the variables obtained are CPI, credit and interest rate as we can see in table 4. Contradictory to our previous results we obtain a negative

relationship between the interest rate and house prices, which is in line with theory. All variables are significant on a five percent level.

	Unstd. Coeff.	t-value	Significance
$\Delta \log \text{CPI}$	-0.943	-4.990	0.000
$\Delta \log \text{Credit}$	0.435	2.431	0.016
$\Delta \log \text{R}$	-0.329	-2.455	0.015
$\epsilon_{Bergen,t-1}$	-0.520	-7.128	0.000

Table 4: Unstandardized coefficients for the short-run model for Bergen. $R^2 = 0.149$. Durbin-Watson test statistic = 1.766 (LL=1.715, UL = 1.803, on a 5% level).

$$\begin{aligned} \Delta \log P_t = & \beta_1 \Delta \log CPI_t + \beta_2 \Delta \log CRED_t + \beta_3 \Delta \log R_t + \\ & + \beta_4 \epsilon_{Bergen,t-1} + \mu_t \end{aligned} \quad (4.5)$$

4.2.3 Trondheim

The variables for Trondheim are the same that we ended up with for Bergen. The coefficients also have the same signs with negative relationships with the house price index for CPI and interest rate and a positive relationship for credit. However, inflation is the only significant variable on the five percent level as we see in table 5 .

	Unstd. Coeff.	t-value	Significance
$\Delta \log \text{CPI}$	-0.803	-4.339	0.000
$\Delta \log \text{Credit}$	0.245	1.548	0.125
$\Delta \log \text{R}$	-0.157	-1.338	0.184
$\epsilon_{Trondheim,t-1}$	-0.242	-3.620	0.000

Table 5: Unstandardized coefficients for the short-run model for Trondheim. $R^2 = 0.1666$. Durbin-Watson test statistic = 1.721 (LL=1.608, UL = 1.763, on a 5% level).

$$\begin{aligned} \Delta \log P_t = & \beta_1 \Delta \log CPI_t + \beta_2 \Delta \log CRED_t + \beta_3 \Delta \log R_t + \\ & + \beta_4 \epsilon_{Trondheim,t-1} + \mu_t \end{aligned} \quad (4.6)$$

4.2.4 Kristiansand

For Kristiansand only inflation and population are significant on a reasonable level. Although the coefficient for the CPI variable is positive as we can see in table 6, which is contradictory to our theory and previous results.

	Unstd. Coeff.	t-value	Significance
$\Delta \log \text{CPI}$	2.559	2.963	0.004
$\Delta \log \text{Population}$	9.396	2.449	0.011
$\epsilon_{Kristiansand,t-1}$	-0.583	-2.582	0.011

Table 6: Unstandardized coefficients for the short-run model for Kristiansand. $R^2 = 0.178$. Durbin-Watson test statistic = 1.777 (LL=1.676, UL = 1.766, on a 5% level).

$$\begin{aligned} \Delta \log P_t = & \beta_1 \Delta \log CPI_t + \beta_2 \Delta \log POP_t + \\ & + \beta_3 \epsilon_{Kristiansand,t-1} + \mu_t \end{aligned} \tag{4.7}$$

5 Conclusion

The aim of this thesis is to find long- and short-term value drivers for real estate prices, using recently constructed long-term data on four Norwegian cities covering a period of nearly 200 years (1819-2003). We use a single equation error correction model and look at value drivers both in a long- and short term perspective. In the long-term perspective, for the aggregated index of the four cities, we conclude that population, income and amount of outstanding loans are the variables that best explain house prices. The population variable has the largest explanatory power, followed by income and outstanding loans. In the short-term perspective, for our aggregated index, the variables that best explain changes in house prices are amount of outstanding loans, CPI and interest rate. Here CPI, which works as a proxy for risk, has the largest explanatory power followed by interest rate and amount of outstanding loans. Naturally, the most important explanatory variables are those that affect the demand since supply is harder to change and land for house building is limited.

Our results are mostly in line with our hypothesis and previous research made in the field. However, contradictory to our hypothesis, we obtained a positive relationship between house prices and interest rate in the short run, implying that a higher interest rate would yield increasing house prices.

Simulations and proper characteristics of the error correction terms established that the choice of using an error correction model was a good one. The error correction term in the short-term model was negative for all regressions and thus counteracting effects of shocks in the explanatory variables.

We want to mention that the results for the cities individually to some extent are less valid than for the results from the aggregated index, due to the fact that data for most of our variables does not exist for each city individually so far back in time as our sample period reaches. Furthermore, some of the variables, such as income, are completely missing regional data.

6 Suggestion for Further Research

The results in this thesis are based on data covering the whole sample period (1819-2003). However, data is not available for all of our variables that far back in time, which might violate our results to some extent, i.e. the extrapolations and interpolations performed in order to attain longer series might not be very accurate. One way to deal with this issue and investigate how this affected our results could be to divide the sample period into different time periods and do the tests individually for these periods.

Examine whether our results are unique for the Norwegian real estate market in any way or if our conclusions can describe long-term drivers outside Norway.

Find a reasonable way to estimate the non city specific variables for each city. This would make the results for each individual city more valid.

Find data for changes in taxes and other regulations that affect house prices. Including these in the model would most likely help to explain some of the abnormal changes in the indices.

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