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Can fundamental factors justify the Norwegian house price development in recent years?

An empirical analysis of the house price development in Norway from 1990 – 2022

Master Thesis

by

Pia Egeberg and Martin Bie Andreassen

Master of Science in Business

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Abstract

This master thesis investigates if the recent run-up in Norwegian house prices can be justified by the development in fundamental factors. By estimating a model of house prices from 1990Q2 until 2022Q4, we find that lending rates, income, and housing construction influence house prices the most. Furthermore, we do not find that house prices are overvalued in relation to a fundamental value determined by *total wage income, housing stock, unemployment rate, banks' after-tax lending rate, and an indicator of households' expectations of their own and the country's economy*. We conclude that the development in Norwegian house prices in recent years, can be attributed to fundamentals and that there is no evidence of imbalance.

Preface

This thesis is written as a part of our Master of Science in Business at BI Norwegian Business School and marks the end of our master's degree.

We want to thank our supervisor, Dagfinn Rime, for providing guidance during the writing process. His feedback has been valuable and much appreciated.

We would also like to thank Norges Bank for their continued support, and we extend our gratitude to Bjørn E. Naug at Norges Bank for providing us with the dataset underlying our analysis. We are grateful for his guidance in achieving desirable estimation results.

Lastly, we would like to thank Ola H. Grytten for sharing his spreadsheet with historical data on the price-to-rent ratio, enabling us to take the analysis one step further.

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Tables and Figures

1. Introduction

The Norwegian housing market has exceeded growth expectations in 2023, showing a 7.7% price increase since the start of the year (Eiendom Norge, 2023). This has happened despite the central bank's policy rate adjustment to address the price growth and its resulting impact on households. The run-up in prices has prompted questions regarding its long-term sustainability.

The state of the housing market is of concern to many Norwegians, as homeownership is often preferred over renting (Sørvoll, 2011). After a long period of housing price growth, with an additional 20% increase during the pandemic (Anundsen, 2022), we experienced a downward adjustment in the latter half of last year. However, this decline was short-lived as prices quickly rebounded through the first half of 2023.

For most households, buying a home is often the most significant single investment throughout their lifetime (Jacobsen & Naug, 2004), and in Norway, 81.8% of the population are homeowners (SSB, 2023d). This is high compared to other countries (Aarland & Sørvoll, 2021). The most recent figures from 2021 indicate that the estimated market value of homes in Norway accounts for 56.06% of the gross wealth of households (SSB, 2022), and according to the Financial Supervisory Authority, the average loan-to-value ratio, i.e., loans secured by residential property, is 64% for new repayment loans (Finanstilsynet, 2022).

It is reasonable to assume that the high debt levels make households vulnerable to a decline in house prices if the value of the collateralized property falls below the total loan amount taken to finance the property. A decrease in house prices could thus have significant implications for activity in the Norwegian economy, as house prices affect household finances and overall economic stability (Jacobsen & Naug, 2004).

Anundsen and Aastveit (2022) stated that higher interest rates would lead to lower demand and hence lower house prices, and the fact that this partial effect has not occurred has created a divided debate in the media. This has made us question whether price increase represents an imbalance in the housing market.

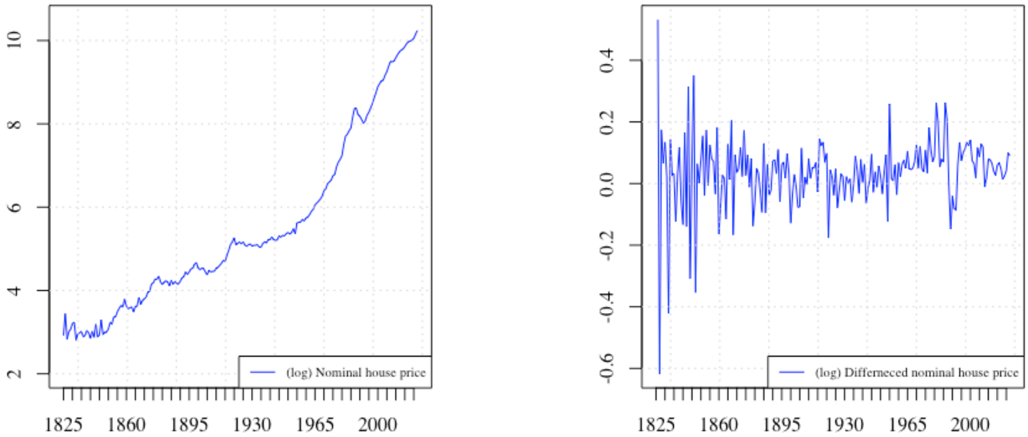
Thus, we want to study if fundamental factors can justify the house price development that has occurred in recent years.

We will apply the model of house prices developed by Dag Henning Jacobsen and Bjørn E. Naug from the Central Bank of Norway. This will be used to determine whether there are indications that the Norwegian housing market has been imbalanced in recent years. This is done by comparing the actual development in house prices against a fundamental value determined by: *total wage income*, *housing stock*, *unemployment rate*, *banks' after-tax lending rate*, *and an indicator of households' expectations of their own and the country's economy*. The original model was estimated from the second quarter of 1990 to the first quarter of 2004. We will extend this estimation period to include data up until the fourth quarter of 2022.

2. Historical development of the Norwegian Housing Prices

Examining historical development in house prices can help us understand today’s levels and gain a perspective. This chapter describes the historical development of house prices in Norway using a house price index that spans from 1825 (Norges Bank, 2023a). The index accurately represents house price trends over time, considering changes in housing quality.

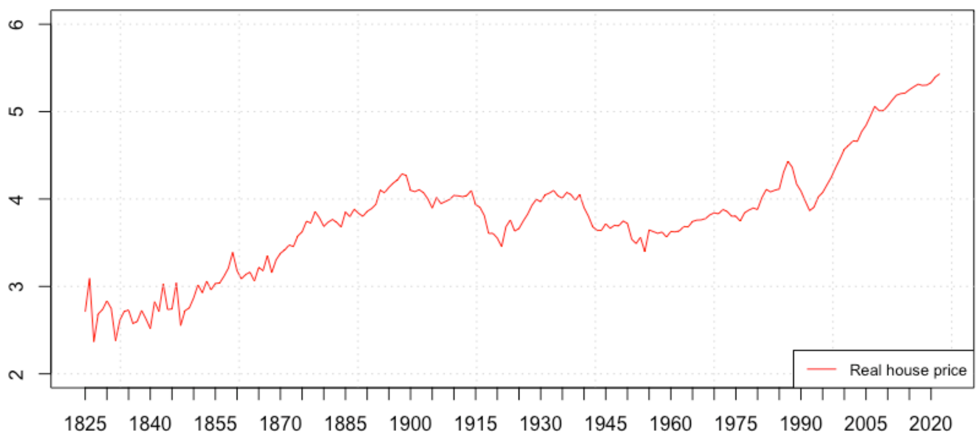
Figure 1: (Log) Nominal House Prices from 1825-2022



As depicted in Figure 1, the era spanning from 1825 to 1920 is marked by significant fluctuations in house prices, as shown in the right panel. However, subsequent to this period, there has been a noticeable increase in stability, with only minor variations in housing prices despite a sharp upward trajectory as shown in the left panel.

Regardless, in Figure 1, the value of money is not considered. To accurately compare historical perspectives, it is necessary to adjust nominal house prices with the consumer price index (CPI). Thus, we deflate the house price index using a consumer price index spanning the same period (Norges Bank, n.d.-a). Figure 2 displays the real house prices, and compared to Figure 1, we see a distinct narrative in real terms, i.e., a more modest overall development.

Figure 2: (Log) Real House Prices from 1825-2022



2.1. The Kristiania Crash

Before the Kristiania crash in 1899, there was a significant increase in Norwegian real house prices. Between 1895 and 1899, house prices in Kristiania rose by 73% (Eitrheim et al., 2004). The price surge was mainly due to the ease in monetary policy and low-interest rates, which resulted in increased economic activity and higher consumer consumption (Grytten, 2013). It led to a speculative wave in securities and real estate, particularly in Kristiania (Norges Bank, n.d.-b).

However, in the fall of 1898 and throughout 1899, the central bank of Norway increased interest rates, causing uncertainty among speculators. As a result, several banks failed (Grytten & Hynnes, 2016), leading to the speculative housing bubble finally bursting in 1899.

2.2. The Depression

During 1906, the housing market recovered and experienced moderate growth in real value. However, this was short-lived, as house prices declined soon after. The incline in house prices was attributed to the complex economic crisis after World War I, caused by factors such as monetary and credit policies, speculation, and inflation. These factors led to instability in the Western economy. Despite a 72% increase in the nominal aggregate house index from 1914 to 1920, the CPI rose by 197% during the same period, as reported by Grytten in 2004. As a result, although nominal house prices peaked in 1920, they significantly declined in real terms due to inflation.

2.3. The Post-War Era

Following the war's end in 1945, there was a severe housing shortage, and the government took on significant responsibility for providing adequate housing (Martens, 2023). During this period, the housing policy mainly aimed to subsidize new developments to assist the population in getting proper housing (Kiøsterud, 2005, cited in Sørvoll, 2021). The government set annual targets for constructing new dwellings, which they tried to achieve through a low-interest rate policy, municipal housing construction programs, and compensation schemes (Sørvoll, 2021).

Due to the high demand for housing at the time, the government also implemented strict regulations of turnover prices and rental rates in the housing market to prevent homeowners and shareholders in housing cooperatives from profiting from the housing shortage. This price regulation ensured that most new housing units, subsidized via the national budget, remained affordable (Sørvoll, 2011). Thus, the housing market remained relatively stable during this period. This heavily regulated policy remained in place until the early 1980s.

2.4. The Banking Crisis

From the mid-1980s, authorities liberalized the housing and credit markets while the central bank pursued a policy of low-interest rates. Excessive credit demand encouraged borrowing for housing consumption and speculation, resulting in a credit and an asset bubble. Easier access to dept amplified the demand for housing and led to a housing market boom, as shown in Figure 2.

From 1984 until 1987, nominal house prices increased by 60%. This enabled refinancing and additional borrowing secured by own property. Thus, an even more significant increase in debt was seen, which could not be serviced with the economic downturn. This led to a collapse in the housing market and financial difficulties for the banks, which faced reduced collateral on their loans (NOU 1992:30).

2.5. From 1993 to 2022

Since 1993, the housing market in Norway has experienced a steady upward trend following the deregulation in the 1980s. Given our dataset, the prices of pre-owned homes between 1993Q1 and 2007Q1 soared by over 348%, significantly outpacing the general price growth of approximately 31% (Norges Bank, n.d.-a) during the same period.

Nevertheless, house prices faced a slight correction once the global financial crisis emerged in 2007. As uncertainty and risk aversion increased, potential buyers became more cautious, leading to a slowdown in housing demand. Additionally, the reduced availability of credit made it more challenging for individuals to secure loans, further dampening activity in the housing market.

Following the global financial crisis, the Norwegian government implemented measures to boost the economy and assist the housing market. Implementations of interest rate cuts and temporary tax relief policies encouraged consumer spending and bolstered the housing sector. These efforts, coupled with a swift recovery in the global economy, contributed to a relatively rapid stabilization of the Norwegian housing market. House prices picked up and started to rise again in 2009 and have reached new historical heights even when exposed to shocks such as the Covid-19 pandemic.

2.6. Summary of the Characteristics of the Previous Crisis

Figure. 2 shows that real house prices had five periods of significant increase, i.e., the 1870s, 1890 to 1899, the 1920s, 1980 to 1987, and during the past 30 years since 1993. We can see from the three middle eras that real prices experienced a considerable decline following the rapid increase. This finding makes the most recent period particularly noteworthy because real price growth has demonstrated a unique continuous development.

After analyzing the patterns in house prices, it is clear that even though each crisis may have unique characteristics (Grytten & Hunnes, 2016), there are still similarities in how they unfold. This is especially evident in low-interest rates' role in making credit more available, stimulating economic growth, and increasing the desire for housing. As a result, house prices, as well as the prices of other goods, rise to a level that cannot be sustained.

3. Literature Review

This section will review previous studies that have examined if the observed price level at the time, can be maintained. The purpose is to examine what previous studies have done to detect if house prices are overvalued and to identify the important fundamental explanatory variables.

3.1. Overvaluation

As a result of the global financial crisis, a considerable amount of existing literature has attempted to understand if the growth could be attributed to economic fundamentals. Although the research field gained much attention, very few were, according to Gerardi et al. (2010), able to predict the bust before it became a reality in 2008. For instance, McCarthy and Peach (2004) and Himmelberg et al. (2005) questioned the substantial rise in house prices and concluded that few signs indicated an imbalance in the U.S. housing market. On the contrary, Shiller (2007) claimed that house prices were overvalued in relation to rent and construction costs, whereas Anundsen (2015) was able to detect a housing bubble at the beginning of the 2000s in hindsight.

Since the 1990s, besides a slight downturn during the global financial crisis and the fall of 2022, Norwegian house prices have reached new heights. This has been noticed by many. Among others, the International Monetary Fund (IMF) has issued warnings about the developments over the years, and Moody's (2017, cited in Anundsen, 2021) claimed that Norwegian house prices had been overvalued since 2010.

In 2019, Anundsen stressed the importance of investigating whether underlying fundamental factors could explain house prices. This was especially important from a policy perspective as the housing market highly influences consumption wealth (Aron et al., 2012) and through interactions with the credit market (Anundsen & Jansen, 2013). This close tie to the real economy makes the housing market critical to financial and macroeconomic stability (IMF, 2017). Thus, detecting imbalances in real-time is important, considering that necessary actions can be taken to prevent further overvaluation and spillover to related markets.

3.2. Bubbles

It is common to consider the existence of bubbles when examining whether house prices are overvalued. Stiglitz (1990) was one of the first to define the term and claimed that a bubble exists "if the reason why the price is high today is only that investors believe that the selling price will be high tomorrow – when fundamental factors do not seem to justify such price" (p. 13). Case and Shiller (2003) emphasized the psychological aspect. They believed that a bubble refers to a situation characterized by a temporary rise in housing prices caused by excessive public expectations about the future price increase.

There are several ways to identify the existence of housing bubbles. A commonly used indicator used to determine if housing prices are inflated is the price-to-rent (P/R) ratio. The P/R ratio is often used when studying the U.S. housing market and tells how market prices develop in relation to rent. A significant increase in the ratio indicates a housing bubble (Grytten, 2009).

However, this technique has been criticized by Himmelberg et al. (2005) as it fails to address the state of housing costs. Relying solely on this measure may create an inaccurate perception of market balance, even if reasonably priced. Anundsen (2021) supported this view and added that even though it is a commonly used metric in the U.S., it is not as suitable for assessing housing prices in Norway due to a relatively less liquid and smaller rental market.

3.3. Studying Fundamental vs. Actual Value

An alternative to the previously mentioned method is the classic fundamental value model (Clark & Coggin, 2011, p. 190). The model first estimates a fundamental trajectory for house prices using the information available, before investigating how actual house prices move in relation to a value implied by the estimated model. This method enables one to detect discrepancies that may suggest an overestimation. Since the P/R ratio seems deficient, we choose to assess specific studies utilizing the fundamental value model in the following.

3.3.1. A Study on What Determines House Prices in 18 OECD Countries

IMF (2004) conducted a study on the real growth in house prices across 18 industrialized countries from 1970-2003. Among these countries, Norway was included. As independent variables, they included: *lagged real house price growth, lagged housing cost as a rate, short-term interest, real growth in disposal income (per. Citizen), real credit growth, lagged real share price growth, a banking crisis dummy variable, and population growth.*

According to the results, each estimate was significant at a 1% level and displayed the expected signs. Additionally, the deviation between actual and predicted value was below 10% for most of the 18 countries, except for Australia, Spain, Ireland, and the UK. The panel model estimation thus explained a significant portion of the run-up in real house prices during the past seven years.

Moreover, real house prices in industrial countries showed a strong persistence as current and previous growth received a correlation coefficient of 0.5. This result indicates that house prices will continue to rise in the following period, given an increase in the current period. The analysis also showed a long-run reversion to fundamentals, whereas misalignments got corrected with 15% per year. Demographic conditions significantly affected long-term house prices, whereas house prices and stock prices did not correlate. Interest and income largely influenced the growth rate of real house prices over time.

After estimating the house prices, a variance decomposition was carried out to group the explanatory factors into four categories: house factor, country factor, global factor, and idiosyncratic factor. The purpose was to determine whether global or country-specific factors influenced changes in house prices. The results showed that the most influential factor differed among the 18 countries.

For Norway, the authors found that idiosyncratic factors, capturing country-specific forces, explained about 75% of the growth in real house prices. Global factors explained 20%, whereas house and country factors explained less than 5%. By comparison, global factors explained as much as 70% of UK and U.S. house prices. The results illustrate the importance of having a country-specific model.

3.3.1. A Cross-Country Analysis on 20 OECD Countries

In 2017, IMF studied the factors driving the increase in house prices in 20 OECD countries, including Norway. According to IMF, the housing supply in

Norway has not been able to meet the demand, resulting in slow price responsiveness. This aligns with Cavallari et al.'s (2019) discovery that Norway's housing supply elasticity was at 1.20, indicating a low supply elasticity that makes the housing market highly sensitive to changes in demand.

IMF (2017) also identified several factors driving the demand for owner-occupied dwellings. These include the solid financial position of households and positive labor and economic market trends such as robust income growth and low unemployment rates. Population growth and urbanization have also contributed to the strong demand.

Additionally, it was suggested that declining interest rates may have played a significant role. Research conducted by Aastveit and Anundsen (2022) supports this idea, showing that expansionary shocks in countries with low housing supply elasticity tend to have a more significant impact on driving up prices than contractionary policies have on slowing them down.

The study discovered that institutional factors played a significant role in the rising trend of housing costs in Norway. Generous tax incentives for housing investments and mortgage financing reduced user costs for homeowners, contributed to the increase. An underdeveloped rental market also added pressure on the owner-occupied housing market.

After identifying important drivers behind the uptrend in house prices, the article investigates the possibility of a housing valuation gap in selected countries from 1990Q1 to 2016Q4. To achieve this, a cross-country housing valuation model was defined, aiming to capture the long-term equilibrium relationship with potential determinants, which included *the housing stock, demand factors, and unobserved housing market characteristics*. Additionally, the study considered the impact of *tax relief* on housing financing costs based on income and mortgage rates. The analyzed demand factors were *real lending rates, real disposable income, population, and consumption*.

The estimation results showed that the model explained 86% of the cross-country and overtime price variation. It also discovered that every regressor had the anticipated sign and was found statistically significant. This suggests that the chosen explanatory variables considerably impact long-term developments in house prices.

Therefore, tax relief, higher income, lower lending rates, and increased household financial wealth all positively influence house prices. On the other hand, a decrease in housing stock relative to the population aged 20 and above, according to the model, will lead to an increase in prices.

To achieve the analysis's objective, IMF (2017) utilized the estimated model to calculate the deviation of actual house prices from the fundamentals' long-term value. The results revealed that the average Norwegian house prices in 2016Q4 were overvalued by 16%. This reflected the highest valuation gap among all 20 OECD countries, although it was slightly lower than the estimated deviation during the peak of house prices in 2007.

3.3.2. A study on Nordic House Prices

In 2021, Anundsen conducted a study to determine if there was an imbalance in the Nordic housing markets from 2000 to 2019. The study aimed to uncover if prices could be attributed to underlying economic factors. Anundsen estimated the fundamental house price path for Denmark, Sweden, Finland, and Norway over the past two decades to achieve this goal.

As with previous research, Anundsen examined real house prices and utilized *disposable household income, housing stock measured by the real housing stock in fixed prices, and the after-tax real interest rate* as fundamental factors. Income and housing stock were measured per capita. The restriction imposed is that they have the same coefficient but opposite signs.

Anundsen emphasized the importance of using country-specific data as it was discovered that the demand elasticity between Norway, Finland, and the U.S. was heterogeneous. Anundsen (2021) followed the methodology in his 2019 publication (Anundsen, 2019) and employed Johansen's (1998) system-based cointegration approach to generate a fundamental house price trajectory from 2000 to 2019.

According to Anundsen's (2021) research, all countries experienced overvalued house prices before the global financial crisis when comparing the fundamental price path trajectory to actual development. In Norway, it was estimated that house prices were overvalued by 17% in 2007. However, Anundsen (2021) also discovered that Norwegian house prices were undervalued until 2016, after which they became overvalued again. At the end of 2019, Norwegian house prices were overvalued by 9%.

3.4. Conclusion of the Literature Review

From the studies presented, it is evident that there are several approaches to studying house price trends. However, there seems to be a general consensus on the primary factors influencing their development, particularly emphasizing the impact of income and interest rates. Additionally, factors such as unemployment, demographics, and housing supply are significant in explaining house prices.

When analyzing the prices of houses in Norway, it is crucial to utilize data specific to the country. Cross-country panel analysis assumes a uniform housing demand elasticity across all sample countries, which is not necessarily true according to Anundsen's research in 2021.

4. Theory

4.1. Supply and Demand in the Norwegian Housing Market

In this section, we will explore the factors that can affect both the supply and demand of housing, ultimately impacting the prices. Our insights are based on an analysis presented by Jacobsen and Naug (2004).

4.1.1. Housing Supply

Supply is according to Jacobsen and Naug (2004, p. 230) reflected through the housing stock, and its impact on house prices is twofold based on the time horizon. Building new residences is time-consuming and laborious, and the annual construction is a small fraction of the overall housing stock. Supply, therefore, exhibits a sluggishness that makes it fixed short-term. While supply is relatively stable, demand may increase, which puts upward pressure on prices. This makes the price homeowners are willing to pay an important barging tool, whereas the person with the highest willingness "wins" the property for sale. In turn, as prices rise, residences become more attractive for developers. This leads to more housing being built, increasing the housing stock over time. Thus, it is common to say that supply adapts to the observed housing demand in the long run.

4.1.2. Housing Demand

According to Jacobsen and Naug (2004), we can split housing demand into two components: household demand for residential purposes and demand for housing as a pure investment object. It is fair to assume that the first component dominates the other, and thus, this thesis emphasizes the first when regarding housing demand. Additionally, we assume households can consume housing services by owning a dwelling.

We consider the following aggregate demand function for owner-occupied residences (Jacobsen & Naug, 2004, p. 231):

4.1) $$H^D = f\left(\frac{V}{P}, \frac{V}{HL}, Y, X\right),\ f_1 < 0, f_2 < 0, f_3 > 0,$$

Where:

H^D = housing demand

V = total housing costs for a typical owner. This captures the alternative cost of owning and consuming a residence for a given time

P = index of prices for goods and services other than housing

HL = total housing costs for a typical tenant (rent)

Y = households' real disposable income

X = a vector of other fundamentals that affect housing demand

f_i = the partial derivative of f(*) with respect to argument *i*

According to equation (4.1), housing demand rises in response to increased real disposable income. When the cost of housing for a homeowner increases in relation to the index of prices and house rents, the demand for housing tends to decrease. This is intuitive because it becomes less attractive to own a home if it becomes relatively more expensive than rentals or other goods/services in the economy. The vector X captures the effect of demographic conditions, bank lending policies, and households' expectations regarding future income and housing costs. The impact of the latter is significant as homes are a long-lasting consumer product, and buying a house is one of the most significant transactions during a lifetime. Additionally, a sizable proportion of the transaction cost is often financed through loans.

The real housing cost for a typical owner can be expressed as (Jacobsen & Naug, 2004, p. 231):

4.2) $$\frac{V}{P} \equiv \frac{PH}{P} BK = \frac{PH}{P} [i(1-\tau) - E\pi - (E\pi^{PH} - E\pi)],$$

Where:

BK = housing cost per real NOK invested in a residence

PH = price for an average residence denoted in NOK

i = nominal interest rate – measured as a rate

τ = marginal tax rate on capital expenses and capital income

$E\pi$ = expected inflation

$E\pi^{PH}$= expected rise in PH - measured as a rate.

$[i(1-\tau) - E\pi]$ denotes the real after-tax interest rate, and the real interest income foregone when investing in a home. From this, we understand that housing costs will increase with higher interest and reduce the demand for owner-occupied housing. The last term in the brackets, $(E\pi^{PH} - E\pi)$, demonstrates the expected real increase in house prices. A positive difference will increase the expected housing wealth, reducing the owner's real housing costs. This makes it more attractive to own rather than rent and boosts the demand for owner-occupied housing.

It is important to notice that the included variables in equations (4.1) and (4.2) influence the demand for housing as a pure investment object for rent. It is safe to assume that the demand for housing as an investment increases with an individual's real disposable income, just like with other demands. House rents increasing more than house prices, lower interest rates, and expecting higher nominal house prices can also make it more attractive to have money invested in real estate.

4.2. Housing Bubble

4.2.1. Definition

The term "Bubble" is frequently mentioned in the media and has various definitions in literature. As there is no single definition, we find it necessary to provide a definition in the context of this thesis. We base our definition on the one provided by Case and Shiller (2003) stated in Chapter 2. However, this statement lacks clarity on the threshold for what price level is deemed excessively high.

Therefore, we provide additional evidence of a potential housing price bubble, as presented by Jacobsen and Naug (2004, p.232). According to their statement, a housing market bubble exists when there is a positive and significant deviation from the fundamental value.

4.3. Price-to-Rent Ratio

We obtain the P/R ratio by executing the following formula (Grytten, 2009):

$$\frac{P}{R}\, ratio = \frac{Housing\ price}{Monthly\ rent * 12}$$

The numerator represents the current market prices for housing, indicating the highest amount a buyer is willing to pay at the time of sale. At the same time, the denominator reflects the earnings acquired from owning a home. The resulting ratio provides insight into the trend of house prices compared to earnings, with a substantial long-term increase being a potential indicator of a housing bubble.

5. A model for the Norwegian housing prices

5.1. About the Model

As of 1992 and up until 2004, house prices had more than tripled, and Dag Henning Jacobsen and Bjørn E. Naug from Norges Bank wondered what might have been the driving forces behind the observed development. As the development in house prices can be crucial for the activity level in the Norwegian economy, they found it important to address this matter. Jacobsen and Naug (2004, p. 230), therefore, argued that when monitoring financial stability, it might be useful to have indicators and models that manage to answer if fundamentals have been responsible for the observed high price levels. Because if the observed growth cannot be attributed to fundamentals, it might indicate a housing bubble.

In an article published in Penger og Kreditt/04, Jacobsen and Naug aimed to construct an empirical model for house prices. Based on quarterly data from 1990 until 2004, they wanted to discover the most important fundamental factors for explaining house prices. Furthermore, they wished to understand how and to what extent housing prices depend on them, as it is important knowledge when projecting housing price developments.

In the search for the most optimal model of house prices, Jacobsen and Naug used a price index for all resale homes as the explanatory variable. They tested the explanatory power of the following variables (Naug & Jacobsen, 2004, p. 233):

- households' total (nominal) wage income
- indices for house rent paid on the total house rent in the consumer price index (CPI)
- other parts of the CPI adjusted for tax changes and excluding energy products (API-ATE)
- various measures of the real after-tax interest rate
- the housing stock (as measured in the national accounts)
- the unemployment rate (registered unemployment)
- backdated rise in house prices
- household debt
- the total population
- the shares of the population aged 20-24 and 25-29
- various measures of relocation/centralization
- TNS Gallup's indicator of the households' expectations concerning their financial situation and the Norwegian economy (the consumer confidence indicator)

In addition to contemporaneous variables, Jacobsen and Naug included lagged variables to account for delayed reactions in house prices. This made the list of explanatory variables long in relation to the number of observations, rendering it implausible to obtain meaningful results when including all variables in one model. Jacobsen and Naug thus estimated a broad range of different housing price models where a limited amount of regressors were included. To simplify the interpretation of the dynamics, they imposed some restrictions on the models that were not rejected by the data.

House rents and other consumer prices received coefficients, and $t - values$ close to zero and were therefore not included in the final model. Additionally, significant effects of market rates, household debt, population movements, or demographic factors were not found.

The authors also found that models featuring a nominal interest rate had a better fit than those with a real interest rate. Therefore, Jacobsen and Naug concluded that it was best to include a relationship between nominal house prices, nominal income, and nominal interest rates.

Jacobsen and Naug found that the most important explanatory variables for house prices were the effects of *total wage income, housing stock, unemployment rate, banks' after-tax lending rate, and an adjusted household expectation indicator*. These variables constituted the preferred model of house prices, and the model was defined as follows:

5.1) $$\Delta houseprice_t = 0.12\Delta income_t - 3.16\Delta\big(INTEREST\ (1-\tau)\big)_t + \\ -1.47\Delta\big(INTEREST\ (1-\tau)\big)_{t-1} + 0.04EXPEC_t \\ -0.12\Big[houseprice_{t-1} + 4.47\big(INTEREST\ (1-\tau)\big)_{t-1} \\ + 0.45unemployment_t \\ - 1.66(income - housingstock)_{t-1}\Big] \\ +0.56 + 0.04S1 + 0.02S2 + 0.01S3$$

The variables are represented in small letters to indicate that a logarithmic scale is used. Additionally, this is an error correction model in the logarithm of house prices and accounts for both short-term and long-term impacts. The short-run elasticity of house prices is defined concerning income, this and the previous period's banks’ average lending rate after tax, and the corrected household expectation.

The term in the squared bracket reflects the long-run elasticity, also referenced as the cointegrating relationship between house prices, banks' average lending rate, unemployment, income, and housing stock. Furthermore, it captures deviations from the estimated long-term relationship in the previous quarter at $t-1$. This is referenced as the error correction term, and its coefficient of -0.12 states that house prices at time t will fall (rise) by 0.12 percent if house prices are above (below) the estimated long-term relationship at $t-1$ (all else equal).

The seasonal dummies, $S_1,\ S_2\ and\ S_3$, are included to account for seasonality in some of the variables. Jacobsen and Naug discovered that income and housing stock were highly correlated once adjusted for seasonal variation. Like Anundsen (2021), they imposed a restriction that income and housing stock have the same impact on house prices, only with opposite signs. Moreover, Jacobsen and Naug did not include unemployment as a lag.

Having estimated the above model, Jacobsen and Naug asked if the high levels of house prices were due to a price bubble or if it resulted from the development of fundamental factors. As Anundsen (2021) and Himmelberg et al. (2005), Jacobsen and Naug (2004, p. 230) saw the P/R ratio as incomplete since it fails to tell if house prices are high relative to rent because of a bubble or the development in fundamentals. Therefore, they sought to investigate the key issue by comparing actual prices with the estimated trajectory following their model.

5.2. A Model for Household Expectation

To capture the effects of household expectations, Jacobsen and Naug included TNS Gallup's indicator of households' expectations concerning their financial situation and the Norwegian economy (Naug & Jacobsen, 2004, p. 234). The indicator is a useful tool for comprehending consumer behavior. As per Finans Norge (Kirkedam, 2023), the concept behind it, is that individuals' belief in their own and the nation's economic future determines forthcoming demand. As such, the indicator is also referred to as the consumer confidence indicator.

The indicator is a cooperation between Finans Norge and Kantar TNS and is a survey conducted by Kantar TNS every quarter on approximately 1000

Norwegians over the phone. The survey has been carried out ever since 1992 and has always consisted of five questions that read as follows (Kirkedam, 2023):

1. Would you say the finances in your household are better or worse than a year ago, or is there no difference?
2. Do you think that the finances in your household will get better or worse in one year, or will there be no difference?
3. If we look at the economic situation for the whole of Norway, would you say that the economy in the country is generally worse than a year ago, or is there no difference?
4. Do you think that the economic situation in Norway will be better or worse in one year, or will there be no difference?
5. Do you think now is a good time for the general population to buy major household items, or is it a bad time?

The indicator is obtained by summing the differences between the optimistic and pessimistic answers for each question, then dividing by the number of questions. A positive value will imply that the majority have positive economic prospects.

Jacobsen and Naug discovered that the variable strongly correlated with banks' average lending and unemployment rates. They, therefore, decided to correct for these effects. This was done by first regressing the TNS Gallup's indicator on banks' after-tax lending rate and unemployment, as in equation (5.2). They proceeded to apply equation (5.3), which determines the difference between the predicted and actual value of the household expectation indicator. As a result, it was possible to isolate changes in expectations caused by factors other than changes in lending rates and unemployment. For example, these factors may include shifts in political conditions or unexpected events like wars or acts of terror.

The model of household expectations constructed by Jacobsen and Naug is:

5.2) $\Delta E_t = -0.07 - 12.96\big(INTEREST(1-\tau)\big)_t - 0.43\Delta unemployment_t - 0.11E - 0.40\big(INTEREST(1-\tau)\big)_{t-1} - 0.03 unemployment_t + 0.21S1 + 0.10S2 + 0.22S3$

From the equation above, we obtain the constructed expectation variable denoted EXPEC, which is a part of the final model of house prices:

5.3) $$EXPEC_t = (E - F) + 100(E - F)^3$$

E is TNS Gallup's expectation indicator, whereas F reflects the predicted value from equation (5.2). The difference between the actual and predicted value will reflect changes in expectations that cannot be attributed to changes in interest rate or unemployment.

6. Methodology

The following chapter explores key concepts in time series analysis to create a groundwork for the later analysis. To begin with, we stress the importance of a stationary time series before discussing cointegration and autocorrelation. Within this, we also present diagnostic tests that can be applied to detect potential flaws within our dataset. Lastly, we introduce the concept of an error correction model, which will be used to estimate the model of house prices. The following discussion is based on Brooks (2019).

6.1. Stationarity

It is important to have stability in a dataset when analyzing the relationship between the variables within. This is achievable if all variables are stationary (Wooldridge, 2016, p. 345). According to Brooks (2019, p. 334), a stationary process is characterized by a consistent mean, unchanging variance, and constant autocovariance at every lag. The latter point concerns the relationship between y and its previous values, and states that the correlation shall only depend on the distance between y_t and its previous observation, y_{t-s}.

The prerequisites for a stationary process can be summarized as follows:

i) $E(y_t) = \mu$

ii) $Var(y_t) = \sigma^2$

iii) $Cov(y_t, y_{t-s}) = \gamma_s$

We deal with a non-stationary process if the above conditions are not met, i.e., a unit-root process, and it is crucial to detect. Being stationary or not significantly impact a series behavior and properties. This can be illustrated by imagining that a series is subject to a shock during a given period. A stationary variable would experience that the effect of the shock gradually dies out, whereas a non-stationary variable would experience that the shock has a permanent effect.

It is important to note that spurious regression can occur when two non-stationary variables are regressed on each other. Although these variables may not be related, they can still produce significant regression coefficients and a high explanatory power, R^2, leading to a false indication of a relationship between them. As a result, the test statistics can become enormously large, limiting our possibility of undertaking reliable hypothesis tests regarding the regression parameters.

6.1.1. Inducing Stationarity

According to Brooks (2019), if a series is non-stationary, we can induce stationarity by taking the first differences. The first difference of a variable, say y, is found by calculating the difference between today's value, y_t, and its subsequent value, y_{t-1} (Brooks, 2019, p.338). A non-stationary series is said to be integrated of order d if it needs to be differenced d times before becoming stationary. This is denoted as $y_t \sim I(d)$.

6.1.2. Testing for Non-Stationarity: Augmented Dickey-Fuller Test

Dickey-Fuller (DF) test tests for unit root (non-stationary process) in time series. The regression under consideration is: $y_t = \phi y_{t-1} + u_t$, and the objective is to check if $\phi = 1$.

A parameter estimate equal to one would indicate that the dependent variable follows a random walk process where shocks persist in the system and never fade out. Alternatively, if the parameter estimate is less than one, the series will wander back to its mean when subject to a shock and is thus proven to be stationary.

For simplicity, we take the first difference of y_t and use it as our dependent variable. Furthermore, we augment the DF test by including p lags of the dependent variable, Δy_t, and thus conduct an Augmented Dickey-Fuller (ADF) test. We run the below regression model:

6.1) $$\Delta y_t = \psi y_{t-1} + \sum_{i=1}^{\infty} \alpha \Delta y_{t-i} + u_t$$

We test if $\psi = \phi - 1 = 0$, which is equivalent to test if $\phi = 1$. The null hypothesis of non-stationarity (H_0) and the alternative hypothesis of stationarity (H_1) is stated accordingly:

$$H_0: \psi = 0 \text{ vs. } H_1: \psi < 0$$

The test statistics is found as:

6.2) $$\textit{test statistics: } \frac{\hat{\psi}}{se(\hat{\psi})}$$

The test statistics are compared against a DF critical value from the Dickey-Fuller distribution. We reject the null hypothesis in favor of the stationary alternative if the test statistics are more negative than the DF critical value.

6.2. Autocorrelation

When conducting time series regressions, it is common to encounter serial correlation, also known as autocorrelation. This issue can cause the OLS estimates to lose their status as BLUE, although they remain unbiased. Consequently, we face inefficient estimates and improper standard errors that are either biased downwards or upwards in relation to the true parameter value. This can, in turn, result in erroneous inferences regarding a variable's impact on y.

6.2.1. Testing for Autocorrelation

Jacobsen and Naug used the Durbin-Watson test to test for autocorrelation. This application, however, is not valid since their model of house prices includes a lagged term of the dependent variable[1]. We, therefore, use the Breusch-Godfrey test to ascertain whether autocorrelation is present.

The model of interest is first estimated using OLS. Next, we extract the residuals, $\hat{u}_t$, and square them. These are then used as the dependent variable in a new regression model. In this auxiliary regression, we include q lagged values of the residuals plus the original explanatory variables in the linear regression model. A regression with two regressors will take the form:

$$6.3)\qquad \hat{u}_t = \gamma_0 + \gamma_1 x_{1t} + \gamma_2 x_{2t} + \rho_1 \hat{u}_{t-1} + \rho_2 \hat{u}_{t-2} + \cdots + \rho_q \hat{u}_{t-q} + \nu_t$$

We state the null hypothesis (H_0) and the alternative hypothesis (H_1) as below. The null hypothesis suggests that no relationship exists between the current error term and any of the q others. The alternative hypothesis states that serial correlation is present.

$$H_0: \rho_1 = 0, and \dots and\ \rho_q = 0 \qquad vs\ \ H_1: \rho_i \neq 0\ for\ \ i = 1,2,\dots,q,$$

The test statistic is found by multiplying the R^2 from regression (6.3) with the number of observations (n) subtracted from the number of lags (q):

$$6.4)\qquad test\ statistics: (n-q)R^2_{\hat{u}_t}, where\ LM \sim^a \chi^2_q$$

Lastly, we compare the test statistics to a critical value following a chi-squared distribution with q degrees of freedom. We reject the null hypothesis in favor of the alternative hypothesis if the test statistic exceeds the critical value. If so, we have reason to believe that autocorrelation exists.

6.3. Cointegration

Despite being non-stationary, two or more series may have a long-term relationship. Such variables are referenced as cointegrated and are characterized by uniting in the long run, even if they deviate in the short term. This is important to establish before estimating an error correction model because the modeling method is inappropriate if a long-run relationship does not exist.

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[1] Not valid due to the clear breach of the third assumption for valid application of the DW test (Brooks, 2019, p. 198).

6.3.1. Testing for Cointegration

To determine if there is a long-term relationship between two or more variables, we can analyze whether a linear combination of them is stationary, as explained by Brooks in 2019. We do so by considering the following cointegrating regression, including k variables:

$$y_t = \beta_1 + \beta_2 x_{2,t} + \beta_3 x_{3,t} + \cdots + \beta_k x_{kt} + u_t \tag{6.5}$$

We can consider the produced residuals from equation (6.5) as a linear combination of the non-stationary variables. This is obtained by moving everything but the residuals to the left-hand side. Furthermore, provided that the non-stationary variables are cointegrated, the residuals become I(0). We can perform a test examining whether the residuals are stationary.

We apply an ADF test on the residuals using the following equation:

$$\Delta\hat{u} = \psi\hat{u}_{t-1} + \nu_t \tag{6.6}$$

The null hypothesis states that the potential cointegrating regression residuals have a unit root, whereas the alternative claims that the residuals are stationary. In the case of stationary residuals, the variables are cointegrated.

The test statistics are calculated as in equation (6.4), whereas Engle and Granger have tabulated the critical value for this application. As before, we compare the test statistics against the critical value and reject the null if the test statistic is more negative than the critical value. If the null hypothesis is rejected, we conclude that the variables are cointegrated since a linear combination does exist. Only then do we estimate an error correction model using the methodology outlined below.

6.4. Error Correction Model

Given that the variables of interest are cointegrated, we employ an error correction model (ECM) to capture the long-run relationship. ECM does so by including a combination of first differenced and lagged levels. That way, the model enables to capture both a short-term and long-term dynamic, as well dealing with the problem of non-stationarity.

A possible ECM estimated for two cointegrated variables would make a regression model of the form:

$$6.7)\qquad \Delta y_t = \beta_0 + \beta_1 \Delta x_{1t} + \beta_2 \Delta x_{2t} + \beta_3 (y_{t-1} - \gamma_1 x_{1t-1} - \gamma_2 x_{2t-1}) + u_t$$

The ECM reflects that y_t change between $t-1$ and t in response to changes in the explanatory variable(s) from time $t-1$ to t. The change in y_t is also in part due to any disequilibrium in the previous period being corrected in this period. The term in the parenthesis is referred to as the error correction term and will be $I(0)$ if the variables are cointegrated. The error correction term is denoted as a lag and demonstrates that the dependent variable does not change instantaneously in response to a disequilibrium. There exists a time dimension.

Coefficients β_1 and β_2 define the short-term relationship between the independent variables and the dependent variable. $\gamma_1$and γ_2 on the other hand, reflect the long-run relationship. The parenthesis measures the deviation from an estimated long-run relationship between the dependent variable and the two regressors. The coefficient of β_3 shows the speed of adjustment towards equilibrium and is bound between 0 and 1 in absolute terms. The closer the parameter is to 1, the quicker the adjustment process is. A long-term relationship does not exist if β_3 equals zero.

6.4.1. Estimating the ECM

Following Jacobsen and Naug, we estimate an ECM using a 1-step procedure. This methodology simultaneously estimates the long-run and short-run relationships, which entails that the cointegrated variable's coefficients and responding $t - values$ must be calculated subsequently.

The methodology is explained below based on Thomas (1997, p.384), and we start by multiplying out equation (6.7). We then get:

$$6.8)\ \Delta y_t = \beta_0 + \beta_1 \Delta x_{1t} + \beta_2 \Delta x_{2t} + \beta_3 y_{t-1} - \beta_3 \gamma_1 x_{1t-1} - \beta_3 \gamma_2 x_{2t-1} + u_t$$

From this, we simplify the coefficients further and reparametrize:

$$6.9)\qquad \Delta y_t = b_0 + b_1 \Delta x_{1t} + b_2 \Delta x_{2t} + b_3 y_{t-1} + b_4 x_{1t-1} + b_5 x_{2t-1} + u_t$$

where:

$b_0 = \beta_0$, $b_1 = \beta_1$, $b_2 = \beta_2$, $b_3 = -\beta_3$, $b_4 = -\beta_3 \gamma_1$, $b_5 = -\beta_3 \gamma_2$.

Equation (6.9) can be achieved by running a regression of Δy_t on Δx_{1t}, Δx_{2t}, x_{1t-1} and x_{2t-1} using OLS. That way, the short-term coefficients can be interpreted directly. However, we must perform some simple operations to define the long-term relationship. With the use of an Excel sheet provided by Naug, we acquire the correct $t - values$ for the cointegrated coefficients by controlling for b_4, b_5, their reported standard deviations, and the coefficients covariance with the lagged dependent variable, y_{t-1}.

We obtain the co-integration coefficients in the error correction term by dividing with the coefficient estimate of y_{t-1}:

$$\gamma_1 = \frac{b_4}{b_3}, \gamma_2 = \frac{b_5}{b_3}$$

This yields the following relationship:

6.10) $\Delta y_t = \beta_0 + \beta_1 \Delta x_{1t} + \beta_2 \Delta x_{2t} - \beta_3 (y_{t-1} - \gamma_1 x_{1t-1} - \gamma_2 x_{2t-1}) + u_t$

7. Dataset and Variables

In this section, we introduce the data material used for the analysis. The sample and regression variables will be described to ensure adequate understanding before the analysis.

7.1. Estimation Period

As the model developed by Jacobsen and Naug effectively explained house prices at its publication, we wanted to create a similar framework using updated data that covers their original estimation period and extends from 2004 to 2022. With Norges Bank's and Bjørn Naug's assistance, we obtained the original dataset, which had been expanded to include data from 1978 to 2022.

Naug informed us that some revisions had been made to the dataset. Thus, we expect slightly deviating results when comparing the re-estimated results to the original coefficient estimates obtained by Jacobsen and Naug. As for the extended period, we expect to receive somewhat different results. In the years that followed 2004, we witnessed various events like the global financial crisis in 2008 and the global pandemic in 2020 that significantly impacted the economy and, thus, are likely to affect our estimates.

7.2. The Regression Variables

In the forwarded dataset, the included variables have been retrieved from the same sources as in Jacobsen and Naug (2004). Jacobsen and Naug have used the price index for pre-owned homes as the dependent variable. It measures the average price per square meter and is corrected for the size of the home, location, and housing type. The index is compiled by ECON Analyse and is financed by FINN.no, whereas Norges Eiendomsmeglerforbund and Eiendomsmeglerforetakenes Forening publish the price index monthly.

Household total (nominal) wage income is extracted from Statistisk Sentralbyrå (SSB), whereas yearly numbers have been converted into quarterly observations. The time series for bank lending rates adjusted for the marginal tax rate on capital income, expenditure, and housing stock measured in fixed prices are also gathered from SSB. The housing stock is measured as in the national accounts. TNS Gallups indicator for households' expectations to own and the country's economy is retrieved from TNS Gallup. The time series for unemployment is gathered from NAV.

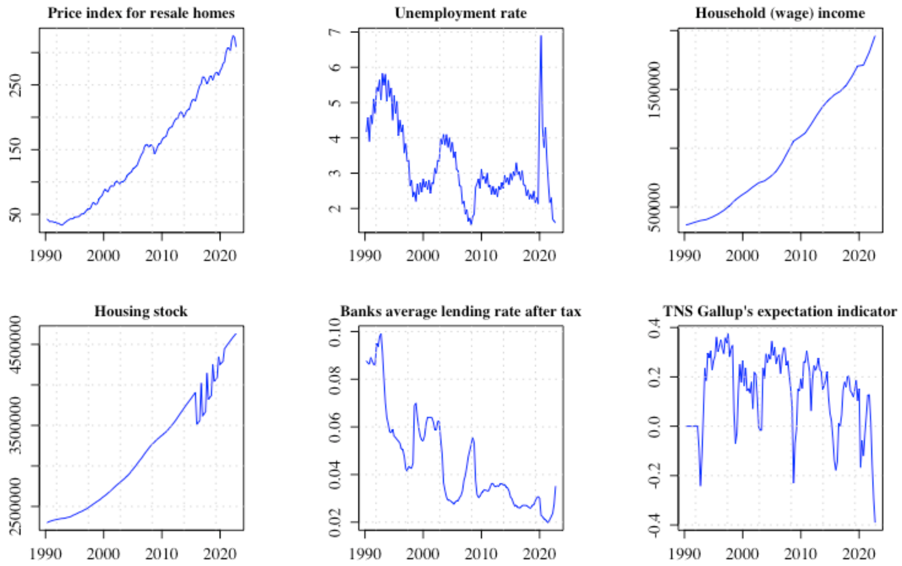
8. Diagnostic tests

The following subsection presents the results from the applied tests, where we seek to discover if the various time series can be classified as stationary and cointegrated. We also check for autocorrelation.

8.1.1. Testing for Stationarity

Below, we have depicted how the time series underlying our analysis has progressed from 1990Q2 until 2022Q4. Through graphical exploration, it appears that every variable, but the constructed EXPEC, is non-stationary.

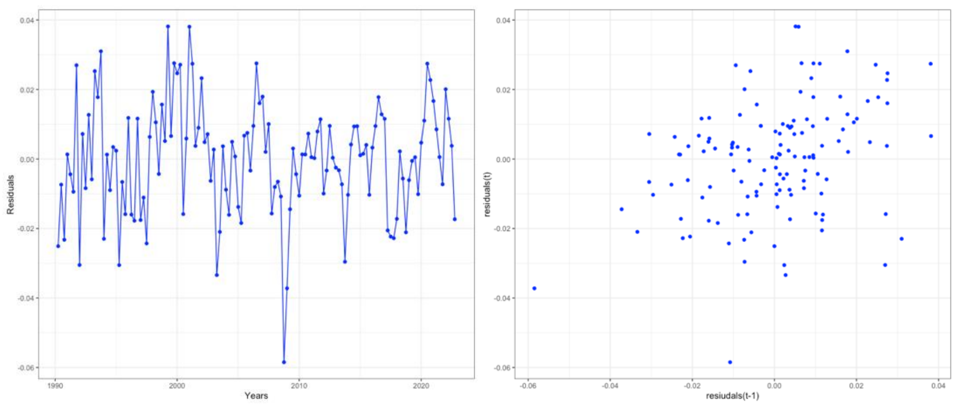
Figure 3: Time series development from 1990Q2 until 2022Q4



Our suspicion can be confirmed (denied) by performing the ADF test, and we choose to test with and without a trend. To find the correct number of lags, we use the Bayesian information criterion (BIC) since the Akaike information criterion (AIC) generally delivers too large models (Brooks, 2019, p.361). Income, unemployment, housing stock, and house price are in logarithmic form in line with the article by Naug and Jacobsen (2004). We find that the constructed expectation variable is stationary with and without a trend (see Appendix 1). Moreover, like Jacobsen and Naug, we get that banks' average lending rate is stationary when testing with a trend. The remaining variables are found to be non-stationary in both cases.

8.1.1. Testing for Autocorrelation

Figure 4: Estimated residuals against time and lagged residual.



The scatterplots do not display a clear pattern. From the left panel in Figure 4, it could seem as if positive observations are followed by negative ones, suggesting a negative autocorrelation. However, the right panel in Figure 4 displays a clustering of points in the top right window that indicates a positive serial correlation. So, to settle this case, we perform a Breusch Godfrey test. We define an auxiliary model including ten lags and extract an R^2 of 0.5677. This is then multiplied by the number of observations, 131, subtracted from the number of restrictions, 10. We obtain a test statistic of 68.6970 and compare it against a critical value of 18.307. Hence, we reject the null and conclude that a relationship exists between adjacent errors. Although this renders OLS no longer being BLUE, we still have unbiased estimates.

8.1.2. Testing for Cointegration

An essential prerequisite for using an ECM is that there exists a long-run relationship between the variables. Therefore, we test if the variables are cointegrated and start by defining the cointegration equation (6.5), where house price is regressed on lending rate, unemployment, housing stock, and income. Next, we apply the ADF test to the extracted residuals.

Through the BIC information criterion, four lags are used in the test. We receive a test statistic of -3.0176. Next, we calculate the critical value following the Engle-Granger test in R-Studio and get a critical value of -2.8839, given a constant and no trend in the cointegrated regression. As the test statistics are more negative than the critical value, we reject the null hypothesis and conclude that the residuals are stationary. Thus, a long-term relationship between the variables exists, and an ECM can be validly estimated.

9. Empirical Analysis

We proceed to the empirical analysis and re-estimate Jacobsen and Naug's model. This will be done on the same estimation period, and our goal is to recreate the original regression estimates to the best of our ability. After that, given desirable results, we apply the estimated model on a broader dataset to estimate Norwegian housing prices from 1990Q2 until 2022Q4. Interpretation of the regression coefficients will be presented at the end.

9.1. Estimating the Model of House Prices from 1990Q2 – 2022Q4

Having obtained satisfactory results when re-estimating the model of house prices (see Appendix 2-4), we continue to estimate the model on the extended estimation period from 1990Q2 until 2022Q4.

9.1.1. Re-estimating the Model of Household Expectations

We begin by estimating the model that corrected the expectation indicator. This is done using OLS based on an estimation period from 1992Q4 to 2022Q4 due to missing observations.

During a meeting with Naug, he advised us to disregard the methodology outlined in the article for determining the constructed expectation variable, EXPEC. Naug suggested we omit the last term in equation (5.3) and utilize the residual directly. Therefore, we computed the variable as follows:

9.1) $$EXPEC_t = (E - F)$$

Table 1 presents the results obtained when estimating the model of households' expectations regarding their own and their country's financial situation. We also include the results presented from the re-estimation for comparison. $t - values$ are given in absolute values.

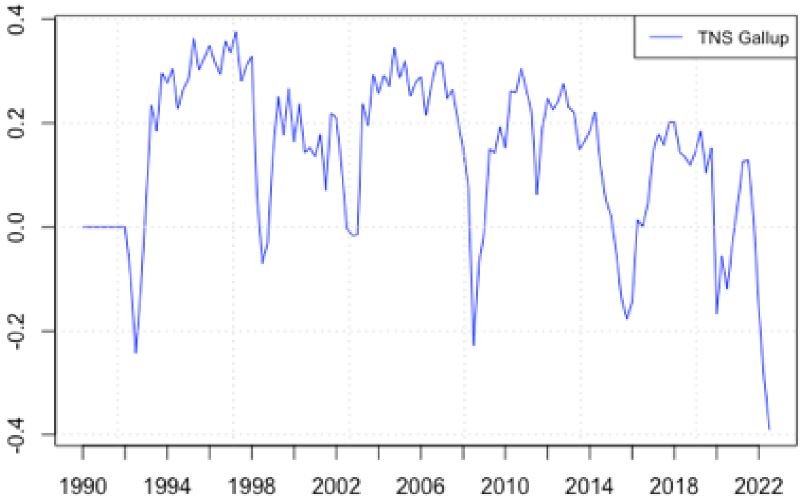
Table 1: Household expectations of their own and its country economy estimated from 1992Q4 - 2022Q4

Variables	**Re-estimation 1992 Q4 - 2004 Q1**		**Estimation 1992 Q4 – 2022 Q1**	
	Coefficient	***t-value***	***Coefficient***	***t-value***
$\Delta(INTEREST(1-))_t$	-12.90***	6.83	-9.97 ***	4.74
$\Delta unemployment_t$	-0.44**	2.54	-0.18 ***	2.75
E_{t-1}	-0.13	1.31	-0.06	1.15
$\Delta(INTEREST(1-))_{t-1}$	-0.65	0.69	-0.15	0.34
$\Delta unemployment_{t-1}$	-0.02	0.61	0.01	0.38
$S1$	0.21***	4.71	0.13 ***	5.56
$S2$	0.09***	4.49	0.05 **	2.55
$S3$	0.22***	5.65	0.12 ***	5.64
Constant term	-0.06	0.86	-0.08 **	2.48
Number of observations	56		121	
R^2	0.81		0.42	
Adjusted R^2	0.76		0.38	

**** significant on 1% level, ** significant on 5% level, * significant on 10% level.*

The extended estimation period has been characterized by a series of shocks and crises, i.e., the financial crisis in 2008, the sharp decline in oil prices in 2014, and the global pandemic in 2020, to name a few. If we study the development of TNS Gallups' indicator in Figure 5, we see that it experienced significant drops around these periods, indicating that the events likely had a significant impact on households' economic outlooks. This, however, is not captured by the model of household expectations, equation (5.2). Instead, it is captured by the residuals, which explains why the explanatory power, $Adjusted\ R^2$, has been reduced from 76% to 38%.

Figure 5: Development of TNS Gallups' household expectation indicator



9.1.2. Estimating the Model of House Prices

To estimate the model of house prices, we must extract the constructed expectation variable, EXPEC, and insert it into a new column in the forwarded Excel sheet. As EXPEC only has variables ranging from 1992Q4, we fill in observations equal to 0 for the quarters before 1992Q4. Jacobsen and Naug also did this, and we were advised to do the same.

Next, we estimate the model of house prices following the 1-step procedure described in chapter 6.4.1. Table 2 displays the achieved regression results, while Appendix 5-7 shows how we obtained the long-term coefficients and the corresponding t-values.

Table 2: Summary statistics of a model of house prices estimated from 1990Q2 – 2022Q4

Variables	Re-estimation 1990 Q2 - 2004 Q1 *Coefficient*	*t-value*	Estimation 1990 Q2 – 2022 Q4 *Coefficient*	*t-value*
Short-term coefficients				
$\Delta income_t$	0.21	0.17	0.43	0.77
$\Delta(INTEREST(1-\tau))_t$	-3.02 ***	5.76	-2.76 ***	5.76
$\Delta\big(INTEREST(1-\tau)\big)_{t-1}$	-1.67 ***	2.69	-0.83	1.65
$EXPEC$	0.04	0.71	0.03	1.36
Adjustment paramteter				
$housingprice_t$	-0.15 ***	4.57	-0.06 ***	3.57
Long-term coefficients				
$INTEREST(1-\tau))_{t-1}$	-4.23 **	2.24	-16.63 ***	3.22
$unemploymen_t$	-0.43 ***	3.40	-0.24	1.28
$(income - housingstock)_{t-1}$	1.64 ***	7,89	1.20 ***	3.42
$S1$	0.04 ***	6.02	0.04 ***	8.88
$S2$	0.02 ***	2.89	0.02 ***	5.079
$S3$	0.002	0.04	0.01	1.399
$Constant\ term$	1.12 ***	4.53	0.46 ***	3.452
$Number\ of\ observations$	56		131	
R^2	0.86		0.70	
Adjusted R^2	0.82		0.66	

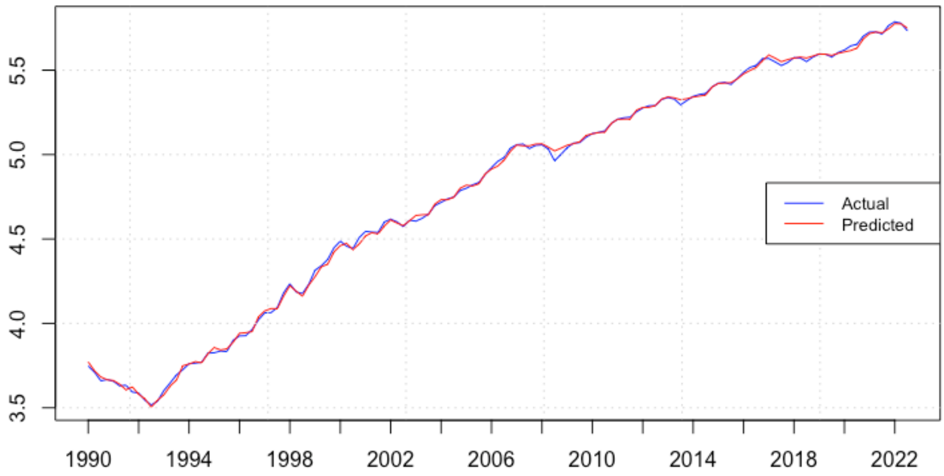
***** significant on 1% level, ** significant on 5% level, * significant on 10% level.*

The extended model of house prices received an $Adjusted\ R^2$ of 66%. This implies that *income, housing stock, unemployment rate, banks' after-tax lending rate, and an adjusted household expectation indicator* now explain 66% of the total variation in house prices. This is less than obtained in the re-estimation, and the explanatory power is thus not as good once the number of observations increases from 56 to 131.

The long-term coefficients and their corresponding $t - values$ are shown in Appendix 5-7. We also notice that the regressors have changed in terms of magnitude and significance level in relation to what we achieved in the estimation period of 1990Q2 to 2004Q1. This is not surprising given the development in the Norwegian economy since 2004. Regardless, we obtain the same direction of partial impact on house prices. This speaks for a robust and consistent model.

As depicted in Figure 6, the estimated trajectory of house prices aligns with development in actual house prices. Thus, this indicates a balanced housing market in Norway and will be elaborated in Chapter 10.

Figure 6: Actual vs. predicted house prices, estimation period: 1990Q2 - 2022Q4



9.2. Interpretation of the Coefficients

In this chapter, we provide an interpretation of the achieved coefficients when estimating the model of house prices based on the extended sample period. We will also discuss how these coefficients have evolved from the re-estimation.

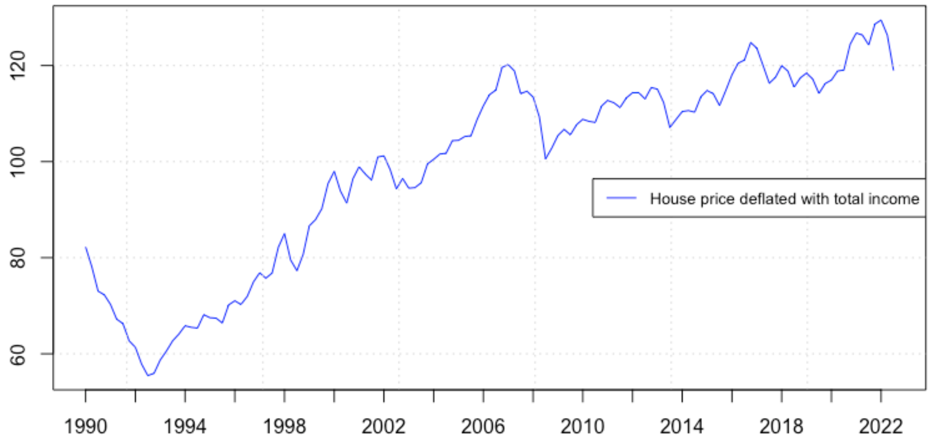
Household (wage) income:

In the first quarter, following the model estimated from 1990Q2 to 2004Q1, house prices are expected to increase by 0.21% if income increases by 1%. However, this effect is strengthened once we estimate the model from 1990Q2 until 2022Q4. House prices are then predicted to increase by 0.43% given a 1% increase in income, everything else equal. Regardless, the effect is insignificant in both estimation periods.

Given the estimation period from 1990Q2 until 2004Q1, house prices are expected to increase by 1.64% in the long run if wage income increases by 1%, everything else equal. When we estimate the model from 1990Q2 to 2022Q4, we get that house prices will rise by 1.20% in the long run if wage income permanently increases by 1%. Both effects are significant on a 1% level, and the results indicate that income has a long-term effect rather than a short-term effect on house prices.

We notice that the long-term elasticity diminishes once the estimation period is expanded. This may be due to a growing relationship between house prices and income. From Figure 7, we see that house prices have been growing at a faster pace than income since the end of the bank crisis in 1992. This could indicate that income may only explain a fraction of the variation in house prices.

Figure 7: House prices deflated with income from 1990Q2 - 2022Q4



Source: House prices and disposal income are from our dataset.

Banks' lending rates:

According to our re-estimated model, house prices will fall by 2.17 %[2] in the first quarter if banks' lending rate after tax increases by one percentage point. From the extended model, we have that one percentage point will decrease house prices by 2.15%[3]. Both estimates are significant on a 1% level, and the coefficients indicate that lending rates quickly affect house prices.

Although the national policy rate increased in 2021, banks' lending rates remained consistent, according to our data. However, during 2022, there was a noticeable upward trend in the banks' lending rates, increasing from 3,54% to 4,51% from Q3 to Q4, respectively. At the same time, there was a decline in house prices, which could be attributed to the rise in lending rates, as suggested by our model.

In the long run, based on our extended estimation period, we have that house prices will decrease by 12,97%[4] in response to a one percentage point increase in banks' lending rates. This reflects a remarkable increase from the re-estimated model, showing that house prices will fall by 3.05%[5] in the long run.

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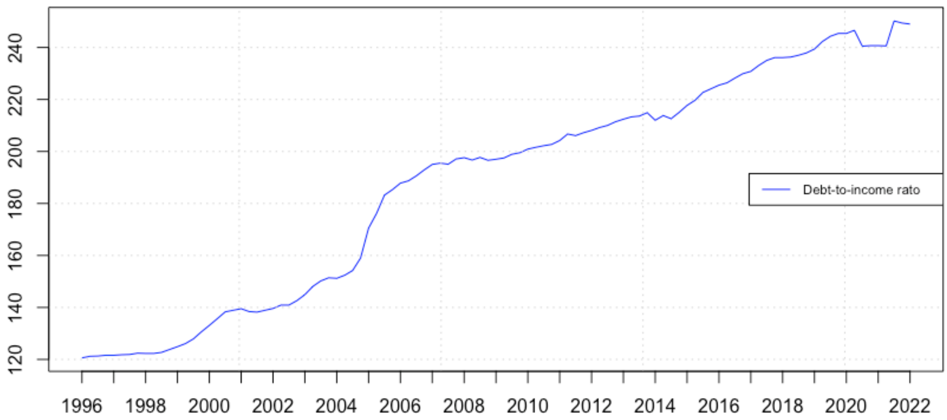
[2] 3.02*(1-0.28) = 2.17
[3] 2.76*(1-0.22) = 2.15
[4] 16.63*(1-0.22) = 12.97
[5] 4.23*(1-0.28) =3.05

It is also higher than the coefficient estimated by IMF (2004), where the model predicted that real house prices would fall by 3.5% in the long run given a one percentage point increase in real interest rates, everything else equal. Thus, our result suggests that house prices have become more sensitive to changes in lending rates in the long run.

In hindsight, this is not that surprising as the household debt burden has reached an almost historical level (Norges Bank, 2022). This is partly due to low lending rates during the past years that may have incentivized households to take on additional loans.

Furthermore, it is much related to the development in house prices, which has grown by 628%. An important implication from Figure 7 is that households must seek loan financing to bridge the discrepancy and stay competitive. Thus, as house prices continue to rise, potential homeowners are forced to borrow more to finance their home purchases (Anundsen & Jansen, 2013). By studying the development in debt-to-income in Figure 8, this becomes evident.

Figure 8: Debt-to-income ratio over the period 1996Q4 - 2022Q4



Source: Debt-to-income ratio is retrieved from SSB (2023c)

The combination of exceptional debt levels and persistently low lending rates, with a decline in fixed-interest loans, has made house prices more sensitive to lending rates as changes may have a profound impact on the affordability of households and, further, the demand for housing. Accordingly, interest has become one of the most significant influences on house prices according to our extended model.

From 2023, banks could offer higher loan amounts to individuals as the stress testing requirement, which involved withstanding a 5-percentage point interest rate increase, has now been reduced to 3 percentage points (Regjeringen, 2023). This is a part of "utlånsforskriften" and expands the borrowing capacity for more individuals, which may maintain the high debt levels and thus the long-run sensitivity of house prices to changed lending rates.

Housing stock:

The estimated model of house prices only incorporates the long-term effect of housing stock. This is consistent with the supply sluggishness established by Cavallari et al. (2019). In the estimation period from 1990Q2 until 2004Q1, we receive a coefficient of -1.64, implying that house prices will go down (up) by 1.64% in the long term if housing stock increases (decreases) by 1%. From the extended model, we receive a smaller coefficient of -1.20. Both effects are significant at 1%.

From 2009 onwards, there was a significant development in the number of housing starts, with a growth of 86,6% from 2009 to 2016 (SSB, 2023a). However, this growth declined in 2016 and has since fallen by 18%. As of today, the market for new dwellings is experiencing a significant decline in sales and building starts (Akershus Eiendom, 2023), which may be attributed to the increasing construction costs minimizing developers' project profit margins.

Based on data from SSB (2023a), the creation of new homes is at its lowest point since the global financial crisis in 2008. The figures show that from March to April of this year, the start of new housing projects decreased by 45.7%, and within the past year, it has dropped by 8.9% (SSB, 2023a). As the overall supply decline, potential homeowners for new dwellings are forced to enter the second-hand housing market, pushing up prices for pre-owned homes and further discouraging the demand for new constructions, ultimately leading to a further decline in housing starts.

At the same time as the supply side is limited, population growth has accelerated due to increased migration and increased life expectancy. From 2022 until 2023, the Norwegian population grew by 1.17% (SSB, 2023b), implying an increased demand for housing. This will ultimately push-up house prices as supply has become almost inelastic.

Unemployment rate:

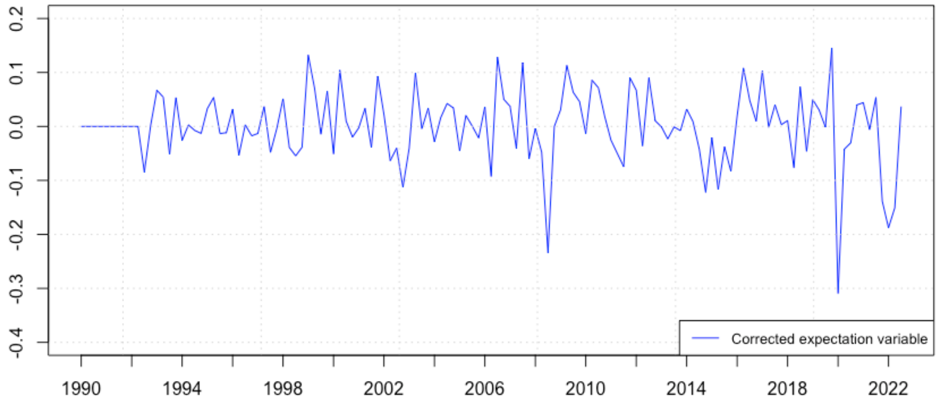
As with housing stock, unemployment is only included in the long-term relationship. However, Jacobsen and Naug did not include unemployment as a lag as they did with the other variables in the error correction term. Thus, this makes the interpretation slightly harder. However, we interpret it as the effect of a 1% change in the unemployment rate at time t on house prices, everything else equal. Thus, house prices will fall by 0.43% if unemployment increase by 1% according to the re-estimation, and the effect is significant at 1%. The effect becomes insignificant and approximately halved to 0.23 once the estimation period is extended towards 2022Q4.

The insignificance is questionable as the Central Bank of Norway attributes the recent growth to the strong development in the Norwegian labor market in their latest monetary policy report (Norges Bank, 2023b). However, our result could be due to not including unemployment as a lag.

The corrected expectation variable:

As the estimation period is extended, the corrected expectation variable receives a reduced coefficient estimate from 0.04 to 0.03. Moreover, the variable is insignificant in both the re-estimated and extended models. This could be due to a relatively stable development in the variable over the estimation period. Although it dropped around the global financial crisis and covid-19, it quickly recovered. Figure 9 confirms this, indicating that expectations for their own and the country's economy due to changes in factors other than observed unemployment and lending rate do not contribute to explaining the house price development.

Figure 9: Differenced corrected expectation variable, 1990Q2 - 2022Q4.



Despite the insignificance, we believe that household expectations impact house prices, and we suspect that expectations are captured through other variables. For instance, it is reasonable that expectations stemming from observed lending rate changes influence current house prices. Expectations for rising lending rates are often associated with decreasing house prices, making people postpone their housing purchases and negatively influencing house prices. On the contrary, positive outlooks can accelerate a purchase in fear of being outcompeted due expectation of rising prices.

The adjustment parameter:

The coefficient in front of the error correction term denotes the speed of adjustment back to equilibrium in the case of a deviation from an estimated long-term relationship between house price, income, unemployment, interest, and housing stock. In the original estimation period, we estimated an adjustment parameter of -0.15 that was significant at a 1% level.

When extending the estimation period, we received an adjustment parameter equal to -0.06, also significant at a 1% level. This indicates that house prices will fall (rise) by 0.06 percent at quarter t if house prices lie above (below) the estimated long-term relationship in quarter $t-1$, everything else equal. Moreover, it shows that house prices will move slowly toward the long-term equilibrium once the estimation period is extended.

9.3. Discussion of Model and Criticism

The model of house prices constructed by Jacobsen and Naug is regarded as a good model for explaining house prices. However, it was constructed in 2004, with an estimated period ranging from 1990Q2 to 2004Q1. This means that the model construction and final estimation were based on 56 observations, which is a relatively small sample.

Moreover, the estimation period only captures the end of the banking crisis and not the course of it. Consequently, we deal with an estimation period characterized by a few significant economic fluctuations. In turn, the model may show a tendency to overestimate the Norwegian house price when subject to shocks. This becomes evident in Figure 6, as the model exhibits a reduced predictive power during the global financial crisis in 2008 and the sharp drop in oil prices in 2014.

Due to a changed economy relative to 2004, it is not unthinkable that some of the variables that were found insignificant could be significant today. For instance, there has been an increase in the population, whereas certain cities have experienced a significant migration. This has especially been the case for Oslo, which has led to an excessive demand amplifying the price increase. Furthermore, as mentioned, there has been a significant increase in mortgages in Norwegian households that are not controlled for either. An additional consideration is the inflation levels today, making it reasonable to assume that real terms might be more appropriate than nominal terms.

Why unemployment was not included as a lag in the error correction term remains unknown. However, it is not very logical. Moreover, the model of house prices only includes one error correction term, meaning that the correction mechanism only takes effect in the presence of a deviation from the long-term relationship in the previous quarter. Due to possible inertia in some of the variables included in the long-term relationship, including more error correction terms could be beneficial.

In Jacobsen and Naug (2004), they provided the DW test value along with their coefficient estimates. However, as mentioned in section 6.2, the application of this test is not valid. When we instead test for autocorrelation using the Breusch-Godfrey test, we get that the null hypothesis of no autocorrelation can be rejected. Consequently, the coefficient estimates provided by Jacobsen and Naug are not BLUE, although still unbiased.

10. Is the Norwegian Housing Market Imbalanced?

In line with our research question, we will now address whether the Norwegian housing market is imbalanced and subsequently understand if fundamental factors can justify the current price levels.

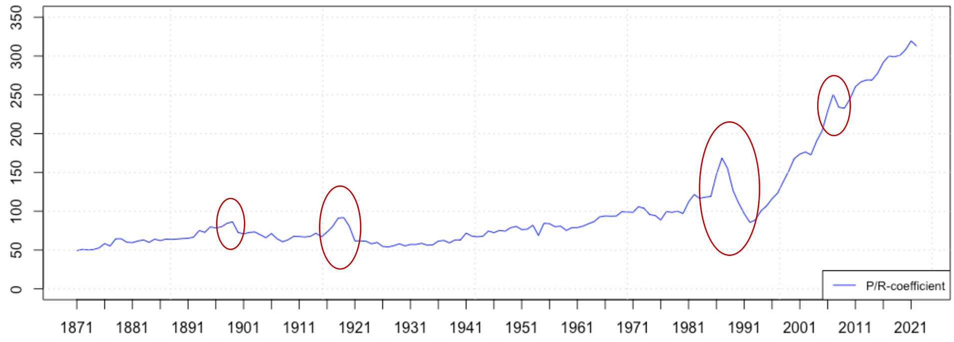
We will explore the development of the P/R ratio to gain a perspective. However, as this measure has some limitations, we will also use the model of house prices to estimate the discrepancy between predicted and actual prices. To understand today's levels, we will discuss various factors that may have contributed to the upward trend in housing prices.

10.1. Price-to-Rent Ratio

In Figure 10, we observe the historical progression of the Norwegian P/R ratio. From the early 1900s until the 1980s, this ratio remained consistent with a slight increase over time, apart from two periods of decline; the Kristiania crash in 1899 and the depression in 1920. However, in the 1980s, we see a steeper increase than before, ultimately reaching an all-time high in 1986. This was followed by the banking crisis, causing a sharp decline. From 1993 to 2007, the P/R ratio increased threefold, indicating that buying a home became three times more expensive than renting. Although house prices plummeted more than rents in 2008, prices quickly rebounded, and the steep upward trajectory continued.

Figure 10 shows a clear bubble outline over centuries, with sharp increases followed by significant drops. Based on the apparent P/R ratio's ability to gauge bubble formation in the housing market, it is difficult to ignore that current levels suggest we may be experiencing the largest housing bubble in history.

Figure 10: Historical development of the P/R ratio 1871 - 2022



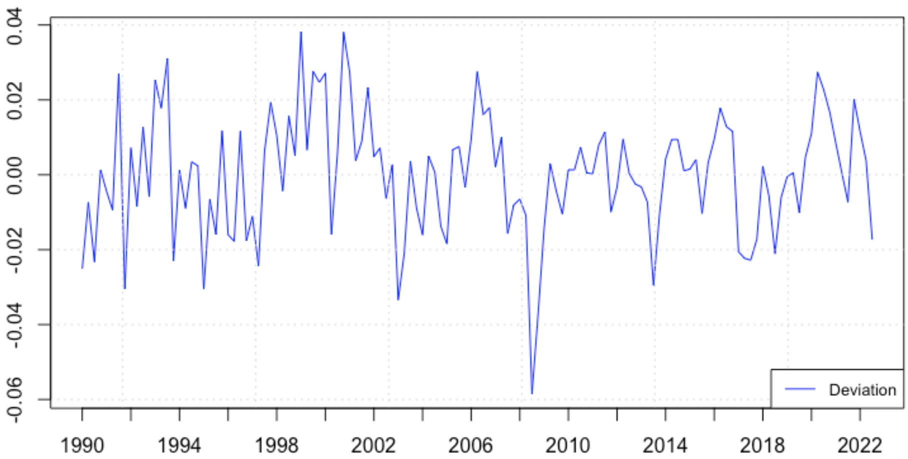
Source: Based on dataset forwarded by Ola Honningdal Grytten, used in Grytten (2009)

Nevertheless, as stated by IMF (2017), it is not easy to detect bubbles in real-time using the P/R ratio exclusively. It is difficult to determine whether high house prices relative to rents result from fundamental development or a bubble, as the measure falls short in providing such information (Jacobsen & Naug, 2004, p. 230). Therefore, we assess the degree of housing market overvaluation by comparing current and reasonable prices based on fundamentals.

10.2. Actual vs. Predicted Value

As previously mentioned in Chapter 9.1.2, it seems that the model's approximations are precise. This is confirmed by Figure 11, which shows that the deviation between actual and predicted values implied by the model is within a reasonable range. Besides a negative deviation of about 6% around the global financial crisis in 2008, it appears only to be minor deviation.

Figure 11: Deviation between actual and predicted house prices



IMF (2004) claimed that a deviation below 10% was considered good evidence for a balanced market. Thus, it does not appear that house prices have been overvalued in relation to a fundamental value determined by *total wage income, housing stock, unemployment rate, banks' after-tax lending rate, and an adjusted household expectation indicator*. Considering this, we have no reason to suspect that the Norwegian housing market has been imbalanced.

11. Conclusion

This thesis has examined *if fundamental factors can justify the Norwegian house prices development in recent years*. In order to answer this, the thesis has utilized an empirical model of house prices based on an estimation period from 1990Q2-2022Q4. This was done to determine if house prices are overvalued in relation to a fundamental value determined by *total wage income, housing stock, unemployment rate, banks' after-tax lending rate, and an indicator of households' expectations of their own and the country's* economy.

Our analysis shows that although there are similarities to the previous crisis, with real house prices and the P/R ratio at record highs, there is no indication of overvalued house prices. We have observed that the trajectory of house prices corresponds well with the actual levels. This suggests that the current prices are not solely driven by expectations for future prices, as suggested by Stiglitz (1990) and Case and Shiller (2003). Instead, our findings suggest that the current prices are supported by fundamental variables included in the model, and there has been no recent positive and substantial deviation (Jacobsen & Naug, 2004). This suggests that the high P/R ratio can be attributed to the development in fundamentals.

We conducted our analysis on an updated and broader estimation period compared to Jacobsen and Naug (2004), resulting in slightly different findings. However, we obtained the anticipated partial effects and identified lending rates, income, and housing construction as the primary factors affecting house prices.

Our research suggests that house prices are highly responsive to fluctuations in lending rates. The short-term coefficient implies that Norwegian house prices should decline by 2.15% in the first quarter, given a one percentage point increase in lending rates, and the other regressors remain unchanged. Furthermore, our analysis indicates a substantial partial long-term effect of lending rates on house prices, i.e., a 12.97% decline in house prices given a one percentage point change in lending rates.

Based on the identified impact on house prices, the decrease in prices in the autumn of 2022 appears to result from the tightened monetary policy, according to Anundsen (2022). However, even with the ongoing rise in lending rates, house prices rebounded in 2023, indicating other factors interfering with the isolated effect of increased lending rates.

Although the IMF (2017) discovered that the Norwegian housing market was overvalued, the factors they identified as driving the upward housing price trend are still prevalent today.

The rise in population, low unemployment rates, and income growth have resulted in high demand for housing. Furthermore, the decrease in interest rates, coupled with the increase in house prices, has likely prompted households to take out loans and invest in the housing market. However, increased demand is met by a housing supply that is limited and slow to adjust. Thus, we experience an upward pressure on house prices, which may explain why increased lending rates do not manifest in the housing market.

Excess demand and good economic conditions have made the market display a resilience that delays the downward pressure associated with rising lending rates. Thus, per our model, and also as suggested by Anundsen (2019), it is not unlikely that house prices will fall in the long run for less desirable development in fundamentals. Particularly if supply can meet the growing number of households and if households with high levels of debt start to struggle to service their financial obligations due to increased lending rates.

A final consideration is that the relaxed lending regulation, i.e., “utlånsforskriften,” is only applied to the end of 2024 (Regjeringen, 2022). If the regulation tightens after 2023, fewer people can participate in the housing market, pushing down prices.

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13. Appendix

Appendix 1: Results from the stationarity test

Variable	***Number of lags***	***Test statistics***	***Test statistics with trend***
$House\ prices$	5	3.737	-1.281
$Income$	1	2.829	-2.512
$Interest\ after\ tax$	1	-1.379	-3.877*
$Corrected\ expectation\ variable$	1	-6.921***	-6.990***
$Unemployment$	9	-1.367	-3.25
$Housing\ stock$	8	3.452	-2.66

Appendix 2: Household expectation of their own and its country's economy estimated from 1992Q4 - 2004Q1

Variables	**From the article**		**Re-estimation**	
	Coefficient	***t-value***	***Coefficient***	***t-value***
$\Delta\big(INTEREST(1-)\big)_t$	-12.96 ***	6.68	-12.90 ***	6.83
$\Delta unemployment_t$	-0.43 **	2.47	-0.44 **	2.54
E_{t-1}	-0.11	1.06	-0.13	1.31
$\Delta\big(INTEREST(1-)\big)_{t-1}$	-0.40	0.42	-0.65	0.69
$\Delta unemployment_{t-1}$	-0.03	0.82	-0.02	0.61
$S1$	0.21 ***	4.57	0.21 ***	4.71
$S2$	0.10 ***	4.49	0.09 ***	4.49
$S3$	0.22 ***	5.61	0.22 ***	5.65
$Constant\ term$	-0.07	0.39	-0.06	0.86
$Number\ of\ observations$	56		56	
R^2	0.80		0.81	
Adjusted R^2	*Not reported*		0.76	

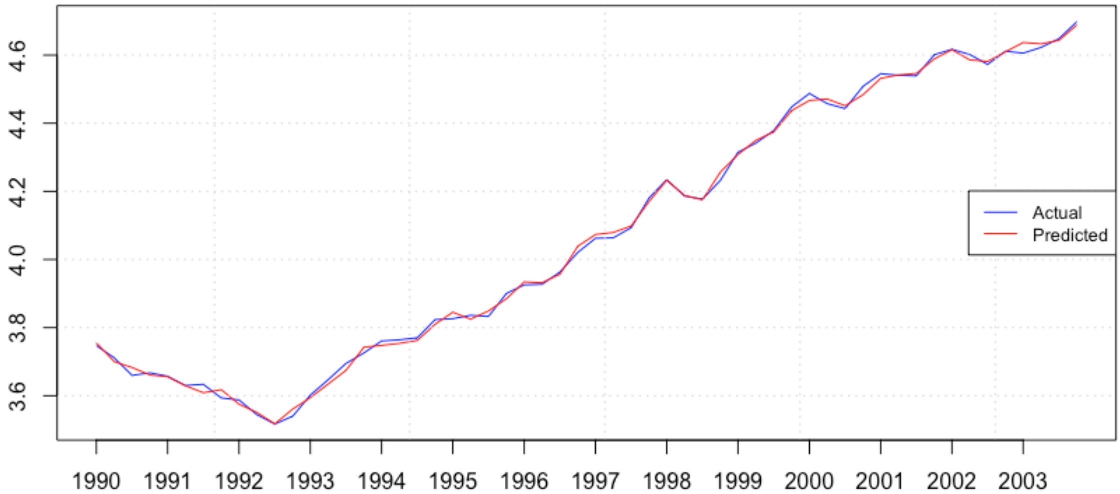
**** significant on 1% level, ** significant on 5% level, * significant on 10% level.*

Appendix 3: Summary statistics of a model of house prices estimated from 1990Q2 – 2004Q1.

Variables	**Jacobsen and Naug**		**Re-estimation**	
	Coefficient	***t-value***	***Coefficient***	***t-value***
Short-term coefficients				
$\Delta income_t$	0.12 *	1.94	0.21	0.17
$\Delta(INTEREST(1-\tau))_t$	−3.16 ***	7.04	−3.02 ***	5.76
$\Delta\big(INTEREST(1-\tau)\big)_{t-1}$	−1.47 ***	3.27	−1.67 **	2.69
$EXPEC$	0.04 ***	3.09	0.04	0.71
Adjustment paramteter				
$housingprice_t$	−0.12 ***	5.69	−0.15 ***	4.57
Long-term coefficients				
$INTEREST(1-\tau))_{t-1}$	−4.47 **	2.54	−4.23 **	2.24
$unemployment_t$	−0.45 ***	3.48	−0.43 ***	3.40
$(income - housingstock)_{t-,}$	1.66 ***	8.63	1.64 ***	7.89
$S1$	0.04 ***	3.35	0.04 ***	6.02
$S2$	0.02 *	1.80	0.02 ***	2.89
$S3$	0.01	0.73	0.002	0.04
$Constant\ term$	0.56	3.42	1.12 ***	4.53
$Number\ of\ observations$	56		56	
R^2	0.88		0.86	
Adjusted R^2	*Not reported*		0.82	

******* *significant on 1% level, ** significant on 5% level, * significant on 10% level.*

Appendix 4: Actual vs predicted house prices, estimation period: 1990Q2 - 2004Q1



Appendix 5: Regression result from 1-step ECM estimation from 1990Q2 to 2022Q4

```
Coefficients:
                         Estimate Std. Error t value Pr(>|t|)
(Intercept)              0.462124   0.133885   3.452 0.000772 ***
d.income                 0.432515   0.561191   0.771 0.442406
d.INTEREST              -2.760853   0.479048  -5.763 6.62e-08 ***
d.INTEREST_1            -0.831562   0.505327  -1.646 0.102487
EXPEC2                   0.031098   0.022940   1.356 0.177790
l.houseprice_1          -0.064176   0.017978  -3.570 0.000516 ***
INTEREST_1              -1.067400   0.183569  -5.815 5.21e-08 ***
l.unemployment          -0.015302   0.010870  -1.408 0.161820
income.min.housingmass_1 0.076870   0.040686   1.889 0.061280 .
S1                       0.041154   0.004633   8.882 8.24e-15 ***
S2                       0.022092   0.004350   5.079 1.42e-06 ***
S3                       0.006234   0.004456   1.399 0.164426
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01688 on 119 degrees of freedom
Multiple R-squared:  0.6918,    Adjusted R-squared:  0.6633
F-statistic: 24.29 on 11 and 119 DF,  p-value: < 2.2e-16
```

Appendix 6: Covariance between the coefficients

```
                          l.houseprice_1
(Intercept)               -2.401295e-03
d.income                  -1.292500e-03
d.INTEREST                -1.865700e-03
d.INTEREST_1              -1.883153e-04
EXPEC2                     4.040565e-05
l.houseprice_1             3.232001e-04
INTEREST_1                 3.906224e-04
l.unemployment            -1.519495e-05
income.min.housingmass_1  -6.739120e-04
S1                        -9.381284e-07
S2                        -4.264078e-06
S3                        -2.043530e-06
```

Appendix 7: Calculation of long-term coefficients and corresponding t-value

Income		Interest		Unemployment	
alfa	-0,064176	alfa	-0,064176	alfa	-0,064176
beta	0,07687	beta	-1,0674	beta	-0,015302
sdalfa	0,017978	sdalfa	0,017978	sdalfa	0,017978
sdbeta	0,040686	sdbeta	0,183569	sdbeta	0,01087
covalfabeta	-0,00067391	covalfabeta	0,000390622	covalfabeta	-1,5195E-05
varalfa	0,00032321	varalfa	0,000323208	varalfa	0,000323208
varbeta	0,00165535	varbeta	0,033697578	varbeta	0,000118157
estimate	1,1977998	estimate	-16,6323859	estimate	-0,238438045
variance	0,12252887	variance	26,73624446	variance	0,034909852
st.dev	0,35004124	st.dev	5,170710247	st.dev	0,19
t-verdi	3,42188199	t-verdi	-3,21665403	t-value	-1,28