Handelshøyskolen BI

GRA 19703 Master Thesis

Final Thesis Master of Science W 100%

Predefinert informasjon

Startdato:	08-01-2024 09:00 CET
Sluttdato:	01-07-2024 12:00 CEST
Eksamensform:	T
Termin:	202410
Vurderingsform:	Norsk 6-trinns skala (A-F)
Flowkode:	202410||11436||IN00||W||T
External assessor:	External assessor 1
Internal assessor:	Internal assessor 1

Deltaker

Navn: Mathias Midtbust Sørbø og Emil Engvik Fosse

Informasjon fra deltaker

Tittel *:	The Norwegian Housing Market: Do current housing prices in Norway, and its four major cities - Oslo, Bergen, Trondheim, and Stavanger - reflect fundamental values?
Navn på veileder *:	Isaiah Hull

Inneholder besvarelsen konfidensielt materiale?: Nei

Kan besvarelsen offentliggjøres?: Ja

G r u p p e

Gruppenavn:	(Anonymisert)
Gruppenummer:	65
Andre medlemmer i gruppen:	

Master Thesis

The Norwegian Housing Market:

"Do current housing prices in Norway, and its four major cities – Oslo, Bergen, Trondheim, and Stavanger – reflect fundamental values?"

by

Emil E. Fosse & Mathias M. Sørbø

Under the supervision of

Dr. Isaiah Hull

Master of Science in Business, Major in Finance

BI Norwegian Business School

GRA 19703 Master Thesis

June 24th, 2024

Abstract

This thesis investigates whether current housing prices in Norway, and its four major cities—Oslo, Bergen, Trondheim, and Stavanger—reflect fundamental values. Using an error correction model, we analyze the short-term and long-term impacts of key economic variables such as total wage income, bank's lending rates, unemployment rates, building permits, and household expectations on housing prices. Our findings indicate significant regional variations, with Oslo showing the slowest adjustment speed towards a long-run equilibrium. The results also highlight the substantial influence of the bank's lending rate and unemployment on housing prices. For instance, a 1% increase in the bank's lending rate leads to short-run housing price decreases of 2.28% in Norway, 2.93% in Bergen, 2.79% in Trondheim, and 2.41% in Stavanger, compared to only 1.33% in Oslo. Unemployment significantly impacts housing prices in all regions except Oslo. Although it is difficult to determine with great certainty whether housing prices are overvalued based on the fundamental variables tested for in our analysis, our data suggests that current housing price trends are unsustainable across all regions, particularly in Oslo, which exhibits significant deviations from these fundamental values.

Acknowledgments

The completion of our master's thesis on the Norwegian housing market marks the conclusion of our MSc in Business – Major in Finance at BI Norwegian Business School, spring 2024.

It has been a rewarding and educational experience to delve deeply into a topic that is frequently discussed in the media and of great interest to us. With numerous perspectives on how the market operates, what drives supply and demand, and the policies governing homeownership in Norway, this has been an exciting subject that has provided us with valuable insights.

In this context, we would like to extend our gratitude to our advisor, Isaiah Hull, for his excellent collaboration, timely and constructive feedback and support, which have been instrumental in guiding us to the successful completion of this thesis.

Oslo, 24.06.2024

Emil E. Fosse

Mathias M. Sørbø

Table of Contents

Figures:

Figure Series:

Tables:

1.0 Introduction

In selecting the topic for our thesis, the housing market emerged as a compelling area of study due to its sustained high returns over several decades and its perception among many as a virtually risk-free asset. The housing market's intriguing dynamics, especially in the context of our personal interest in real estate investments, encouraged our decision to delve deeper into its complexities. Our objective is to acquire a more nuanced understanding of market behavior, which could inform strategic decisions about entering or exiting the housing market.

The recent trend of escalating house prices, notably outpacing the growth in total wage income in the Norwegian economy, presents a critical area for investigation. In the span of the last 25 years, the Norwegian housing market as a whole has witnessed a growth of 386% (Finn.no, Eiendomsverdi, EFF, NEF and Eiendom Norge, 2024). In the same period, the CPI in Norway has increased 85%, which goes to show that housing prices have risen at a rate more than four times that of general inflation over the last 25 years (SSB, 2024). In Oslo, this growth has been even more extreme, with an increase in housing prices of 497% over the last 25 years (Finn.no, Eiendomsverdi, EFF, NEF and Eiendom Norge, 2024). We aim to examine this phenomenon to determine whether it represents a sustainable trend or is a precursor to a potential market adjustment. This analysis is particularly relevant in light of our aspirations to engage actively in the housing market.

Our research question thus emerges as follows: "Do current housing prices in Norway, and its four major cities - Oslo, Bergen, Trondheim, and Stavanger - reflect fundamental values?". This question warrants closer examination due to the long-term growth observed in this market. If today's prices indeed represent fundamental values, how can this be verified? And if not, to what extent do they deviate from these values?

Our study aims to look at historical trends, and based on this, forecast future trends and understand its sustainability as a crucial investment domain. Along with our main research question, we also seek to answer questions such as: Will the housing market sustain its growth, achieve stability, or face a downturn? We believe this question is vital, not only in assessing the future prospects of the housing market, but also in evaluating its sustainability as a long-term investment opportunity.

Positioned against a backdrop of persistent growth in the housing market over the last decades, our research will investigate whether this growth can continue at the same pace. In Norway, particularly, there exists a disparity between the rates of housing price increases and the growth of other key economic indicators, such as the CPI, total wage income, and rent income from leasing activities. This deviation prompts our investigation into whether current housing prices accurately reflect their underlying fundamental values or if they diverge significantly from these benchmarks.

To add depth and consistency to our study, we propose a multi-faceted comparative analysis. First, we plan to contrast current housing price trends in Norway with historical periods in the country, delving into the cyclicality and potential sustainability of these trends. Such a historical perspective will provide a comprehensive understanding of the market's evolution and recurring patterns.

We also look at and compare the growth of Norwegian housing prices compared to that of financial assets, offering insights into relative investment returns and associated risks. For reference, the benchmark index for Oslo Stock Exchange, OSEBX, has increased about 606% over the last 25 years (LSEG, 2024). This is a greater return than that of the overall housing market in Norway (386%) and in Oslo (497%) over the same period. Another important aspect we examine is the impact of leverage on housing investments. Whereas most investors use loans to finance their real estate investments, it is less common to leverage other investments such as investments in the stock market, at least for individuals. For example, a 497% return in something that has been leveraged 3x is greater than the return of an unlevered investment in the stock market with a return of 606%, everything else held constant. This comparison will aid in comprehending the investment landscape and the positioning of real estate within it.

The impact interest rates have on the Norwegian housing market is also examined. Looking at the distribution of debt between floating rate and fixed rate on bank loans, as of Q4 2023, 94.5% of all loans given out by banks have a floating rate, whereas only 5.5% of loans have a fixed rate (SSB, 2024). Norwegians are also among the most levered countries in the world when it comes to debt relative to income. According to OECD, Norway had the highest debt-to-income ratio among all the 38 OECD member countries with a DTI-ratio of 247% of net disposable income in 2022. As a comparison, the DTI-ratio of the United States was only 102% of net disposable income in the same year (OECD, 2024). This, along with the high concentration of floating rate mortgages should make the Norwegian economy highly sensitive to changes in interest rate, more so compared to that of other countries where fixed-rate loans/mortgages are more common.

In Chapter 7 and 8, we construct econometric models, utilizing OLS and Error Correction Models to understand the determinants of housing prices from Q1 1997 to Q4 2023. Our findings reveal that the bank's lending rate and unemployment are the most significant factors influencing housing prices. The explanatory power of our housing price models ranges between 63% and 77% for Norway, Bergen, Trondheim, and Stavanger, but only 45% for Oslo, demonstrating greater signs of deviations and potentially indicating influence from additional unobserved factors not captured by our models. For instance, Oslo exhibits the slowest adjustment speed towards a long-run equilibrium, with a halving time of approximately 22 quarters (5.5 years), compared to Stavanger's 15 quarters (3.75 years). This slow adjustment suggests prolonged deviation from fundamental values.

Despite the notable alignment of housing prices with fundamental factors, our data suggests that current housing price trends are unsustainable across all regions, particularly in Oslo, which exhibits significant deviations from these fundamental values. Notably, Oslo's housing prices have outperformed other regions by 140% since 1997. Additionally, we observe that housing prices across all regions have significantly outpaced both inflation and total wage income over the last 26 years. The gap between housing prices and rent income has increased by 43 points in Oslo, 19 points in Bergen, 29 points in Trondheim, and 11 points in Stavanger from Q1

2012 to Q4 2023. Furthermore, private housing prices have increased significantly relative to the commercial real estate office sector, highlighting a significant disparity in market performance. For the first time since 1990, the cost of owning a rental property exceeds rental income, resulting in a negative yield gap in Oslo. Given these trends, we find that housing prices will likely need to decrease eventually.

2.0 The Norwegian Housing Market

The Norwegian housing market has long been regarded as a safe and long-term investment strategy. Apart for certain crisis periods, the market has steadily risen without significant interruptions. To better understand the market and to conduct the analysis desired for our thesis, it is crucial to examine the periods when crises occurred, understand why they happened, and determine if similar patterns or situations are reflected in the current market. By studying historical events that have impacted the Norwegian economy, we can assess whether this remains a wise long-term strategy in the face of potential new crises.

2.1 Kristianiakrakket

“Kristianiakrakket” was the first crisis in recent times to impact the Norwegian economy. Primarily dating back to 1899, the crisis had its foundations laid over time. During the period from 1893 to 1899, the population, particularly in the urban centers of Norway, experienced significant growth. This surge in urbanization was accompanied by a massive construction boom to meet the sudden surge in demand. Much of this was made possible for both developers and private individuals as financing could be secured through mortgage-backed securities[1]. The crisis became a reality when the stock market experienced a considerable decline in April 1899, causing fear to spread quickly throughout the market (Norges Bank, 2024). Housing prices collapsed along with the stock market, but the crisis had the greatest impact on prices in Oslo. There were significant regional variations within the country, with Bergen being far less affected, and prices in Trondheim and Kristiansand remaining unchanged.

[1] A mortgage-backed security (MBS) is a type of financial instrument that pools together a collection of mortgage loans and sells the resulting cash flows to investors.

Figure 1: Kristianiakrakket – Norway HPI (1890-1910)

Source: Norges Bank

2.2 First World War

From the onset of World War I (1914) until the end of World War II (1945), the world economy, including Norway's, experienced an unstable period. Although Norway was not an active nation in WW1, the invasion and a generally unstable period led to a loss of control over the economy. To finance the various wars, an expansive monetary policy was implemented in several countries, including Norway. This policy resulted in significant inflation, weakening the economy. This expansive monetary approach led to a doubling of money and credit volume (Norges Bank, 2024). While prices of most goods and services were increasing, there was a scarcity of goods in the country, as most domestically produced goods were exported to meet the war's demands.

By examining the housing prices during this period graphically, we can observe the strong growth during World War I and how this growth subsided. At their peak, housing prices grew by 207% from 1910 to 1920, before crashing approximately 15% in the subsequent years:

Figure 2: Time Period before and after World War 1 – Norway HPI (1910-1930)

Source: Norges Bank

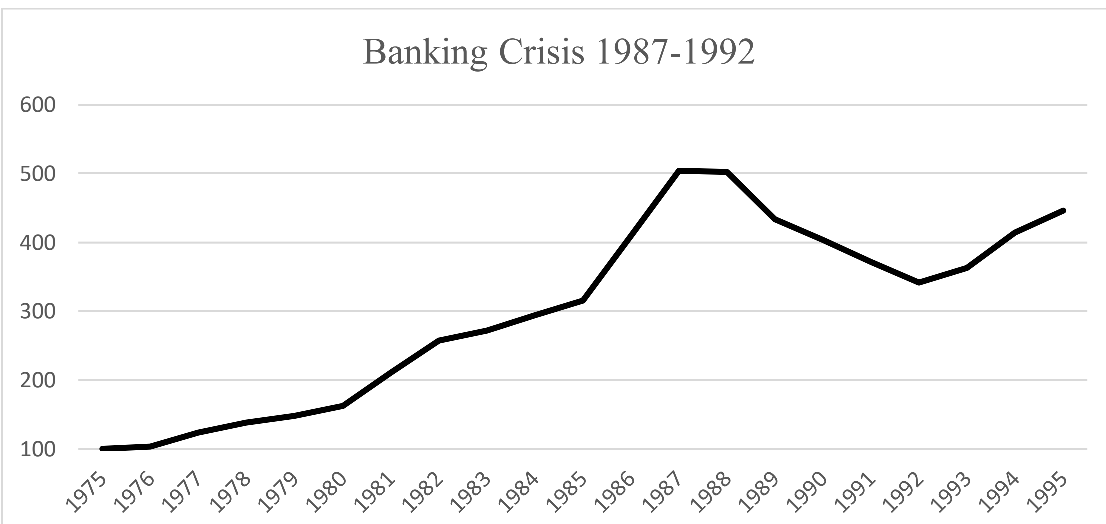
2.3 Post World War II (after 1945) and the Banking Crisis (1987-1993)

Following decades of economic uncertainty intensified by global conflicts, the period of sustained peace significantly fostered growth within the Norwegian housing market. This growth was driven by several factors, including a robust population increase due to the baby boom after WW2, minimal regulatory constraints, and an optimism linked to peacetime, which restored confidence in investment profitability (Tønnessen, 2019). Until the late 1970s, the market remained relatively stable, however, a conjunction of major changes in both international and domestic economic landscapes facilitated greater freedom and liberalization, leading to perfect conditions for a sharp increase in housing prices. Notable influences such as low interest rates, the discovery of oil reserves, and institutional confidence in the markets spurred significant rises in consumption and demand. This upward trend continued until it peaked in 1987, marking the onset of Norway's first post-war recession, characterized by economic stagnation, a national banking crisis, and numerous bankruptcies. The resultant correction in housing prices saw a steady decline until 1993 (SSB, 1999).

During the prosperous era preceding the banking crisis, spurred by the oil adventure, Norway benefited from favorable lending conditions that led to a substantial surge in loan growth. This was concurrent with a deregulation of the credit markets. However, the banking sector, unaccustomed to such unfettered conditions following years of stringent regulations, found itself struggling to adjust when the market conditions deteriorated. The decline in oil prices, coupled with diminishing confidence in the Norwegian krone, prompted the government to implement contractionary fiscal and monetary policies starting in 1986. To bolster public confidence and prevent further financial turmoil, the Bank of Norway intervened to ensure liquidity among the banks. In response to the ensuing financial instability, the government established the State Bank Insurance Fund and the State Bank Investment Fund, initiatives aimed at injecting equity into several of the country's largest banks (Moe, Solheim, & Vale, 2004). Following a significant write-down of shares, these capital injections effectively rendered the state a major bank owner.

As indicated in Figure 3, from 1975 to 1986, housing prices surged 404%. Despite the severe economic challenges that followed, through substantial interventions and active involvement by the Norwegian Central Bank, the country navigated through these turbulent times and eventually saw recovery in 1993 as international economic conditions began to improve.

Figure 3: Banking Crisis – Norway HPI (1975-1995)

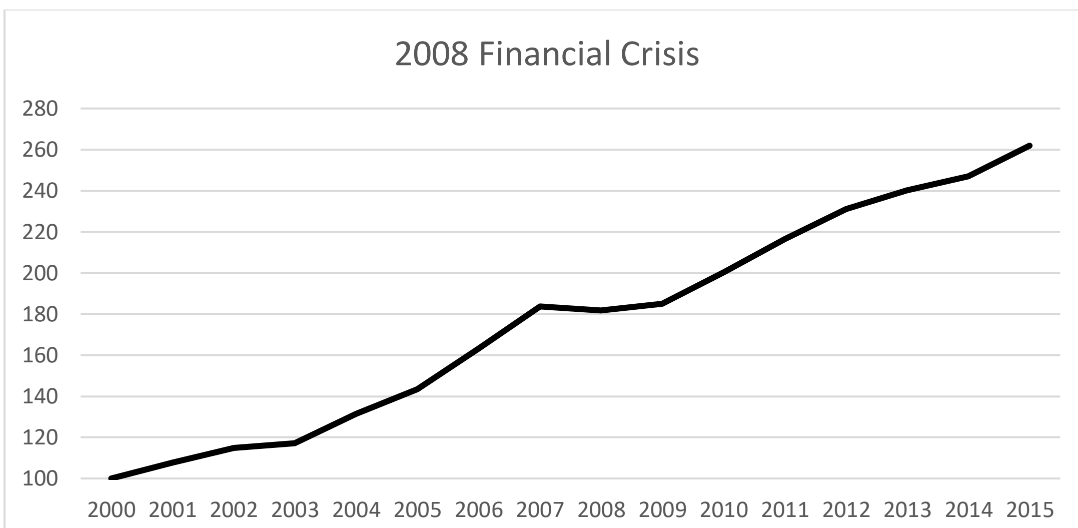


Source: Norges Bank

2.4 The 2008 Financial Crisis

After several years of strong growth in both the international and national economy, the world once again encountered a new financial crisis in the fall of 2008. The issuance of loans to private and professional actors without sufficient repayment ability, coupled with the continuous belief that the housing market would keep rising, were key reasons for the burst of the bubble. The international bank Lehman Brothers went bankrupt, and faith in and the trust towards banks plummeted once again. On a national level, the Bank of Norway was quick to act, injecting liquidity into the money markets, including by lending US dollars to Norwegian banks. The policy rate was lowered, and the situation was quickly averted domestically through these measures. The developments in American banks, where the loan crisis originated, led to downturns in international markets. Overall, Norway was minimally affected by this crisis compared to other countries, largely due to strong state finances through high oil revenues. Looking back at this crisis, it revealed significant deficiencies in the international banking system, where the requirements for repayment ability and bank security were subsequently placed on the agenda.

Figure 4: The Financial Crisis – Norway HPI (2000-2015)



Source: Norges Bank

2.5 Summary: Economic Crisis in the Norwegian Economy

To summarize, there have been three crashes that have had a significant impact on the Norwegian economy: the “Kristianiakrakket”, the First World War with its post-war period, and the banking crisis in 1987-1993. The financial crisis of 2008 is also mentioned, but due to effective economic management by the Norwegian state, Norway avoided major downturns during this period, though regional market fluctuations were observed.

Common factors across all crises included rapid and significant growth in the money supply, high levels of debt, significant urban migration, and expectations that the economy would continue to rise. Each period was followed by a recession and tighter economic times. Each crisis has its own characteristics, and the knowledge we have gained from these is valuable information that must be considered in the future to learn from past mistakes in order to avoid crises in the coming periods.

2.6 Regulations in the Norwegian Housing market

The Norwegian housing model is designed to maximize homeownership among its population (Eiendom Norge, 2024). Despite minor adjustments over time, the overarching policy objective in Norway has consistently been to promote homeownership. This policy is confirmed when we look at the number home ownership compared to renting homes. As of Q4 2023, 76% of households own their own homes, while 82% of private individuals own their homes (SSB, 2024).

Historically, particularly throughout the 20th century and beyond, stringent regulations were associated with housing, ranging from borrowing limits to construction controls. However, the housing sector has become increasingly liberalized in recent decades (Sørvoll, 2011).

Table 1: Historical regulations in the Norwegian Housing Market

Regulations of the Norwegian housing market

Type of housing	Period	Type of regulation
Rental dwellings	1916-1935	Rent control on some types of flats.
	1940-2010	Rent control on some types of flats.
	1976-1983	Condominium conversion forbidden.
Owner-occupied dwellings	1940-1954	Price freeze.
	1954-1969	Price regulations.
Housing co-operatives	1940-1954	Price freeze.
	1954-1982/88	Price regulations on new/old flats
	1976-1983	Condominium conversion forbidden.

Source: (Erlandsen & Eitrheim, 2004, p. 7)

Among the outstanding factors influencing housing prices and availability, governmental policies, particularly property taxation, play a significant role. Since 2007, property taxation has been decentralized in Norway, allowing municipalities to independently decide whether to increase or decrease this tax. Compared to other OECD countries, Norway ranks low in terms of property and housing taxation (OECD, 2024). Low taxes and mortgage interest deductions may explain why property prices in Norway have risen significantly in modern times. Coupled with prolonged periods of low interest rates, the overall cost of property ownership has been low, thus potentially driving the increase in property prices.

3.0 Data Sources

In this chapter, we present the data utilized to construct a comprehensive housing price index. Our analysis draws from two distinct housing price indices, each covering different time periods. Fortunately, these indices overlap, making it possible to construct one cohesive housing price index for our analysis of the Norwegian housing market as a whole, along with Norway's four largest cities: Oslo, Bergen, Trondheim, and Stavanger.

3.1 The Real Estate Industry's Housing Price Statistic (1985-2013)

The real estate industry's housing price statistic is compiled through a collaboration between the Norwegian Association of Real Estate Agents (NEF), ECON, the Association of Real Estate Agencies (EFF), and Finn.no. ECON is responsible for the actual preparation of these statistics. Up until 2001, the housing price data was based on voluntary reporting by NEF members. Since then, it has relied on sales mediated by agents who are members of NEF and EFF and advertised on Finn.no. This change in data collection procedures in 2002 resulted in recording 2-4 times as many transactions from 2002 to 2010 compared to 2001.

The housing price index (HPI) was published on an annual basis from 1985 to 1989. From 1990 to 1996, it was published quarterly, and from 1997-2013 it was published once a month. The statistic covers the price per square meter for detached houses, semi-detached houses, and apartments from 1985 to 2013. These prices are weighted to form national averages for each housing type, as well as an overall national average for all housing types. The calculations use a hedonic model, which estimates property values based on characteristics like housing type, location, and the number of square meters. This model uses significantly fewer variables than the new housing price index that will be presented in the next section (Section 3.2).

3.2 The Real Estate Industry's Housing Price Index (2003-2023)

This HPI spans from 2003 to 2024 and includes 80 different geographical divisions. The Real Estate Industry's Housing Price Index is created in collaboration between

Eiendom Norge[2], Eiendomsverdi, and Finn.no. This price index replaces the previous statistics from 1985 to 2013. The data is based on sales mediated by real estate agents and advertised through Finn.no, while the statistics themselves are prepared by Eiendomsverdi AS.

The index is based on a hedonic model that includes up to a hundred different explanatory variables related to the characteristics of the properties. This makes the index probably the most comprehensive housing price index in the country. Since the index is meant to capture price changes related only to housing, data for land and garages are excluded.

The creation of the index is carried out in two steps. First, observations of how variations in housing characteristics, such as type, size, floor, lot size, year built, ownership, location, and number of buildings, correlate with sale prices are analyzed. Using a regression model, a partial price for each characteristic is estimated, which is then summed to an assumed total value for the property. In the second step, the ratio between the latest sale prices and the predicted prices based on the regression model is calculated. For each area, a typical price increase is determined by identifying the median ratio of observed to predicted prices. The median level indicates the price increase where fifty percent of the observations are lower, and fifty percent are higher. This approach controls for compositional effects and varying price trends across different property types, allowing for an assessment of price development for comparable properties (Eiendom Norge, 2024).

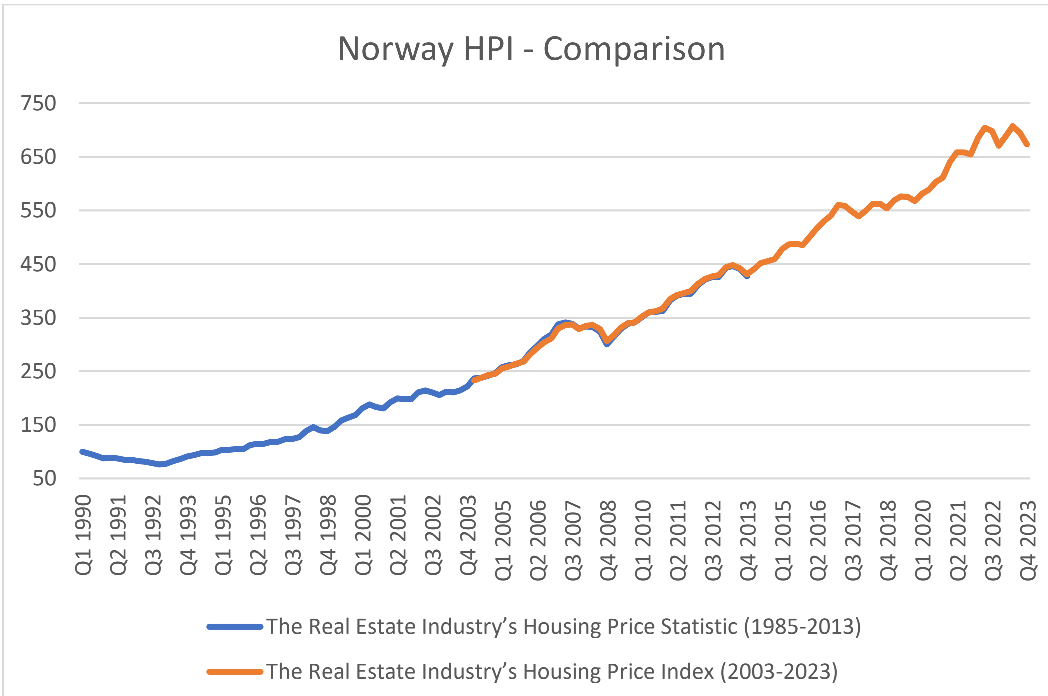
3.3 Construction of Housing Price Index (Q1 1990 – Q4 2023)

Based on the two HPI's we described in Section 3.1 and 3.2, we have constructed a new housing price index for Norway, Oslo, Bergen, Trondheim, and Stavanger. Since we are using quarterly data in our econometric analysis later in the thesis, the starting point of our constructed HPI is Q1 1990. This is due to the lack of available quarterly statistics for all housing price variables prior to 1990, as far as we are aware. We utilize "The Real Estate Industry's Housing Price Statistics (1985-2013)" from Q1

[2] EEF changed its name to Eiendom Norge in April 2014 (Eiendom Norge, 2014).

1990 before merging this with "Real-Estate Norway's Housing Price Index" from Q1 2004 and onwards. Upon examining the graphical representation and indexed values of the two overlapping HPIs, we observe very minor deviations between the two statistics in certain periods. Notably, from 2004 to 2006, the data shows minimal discrepancies. Therefore, we chose to merge the two datasets during this time period to ensure consistency and continuity.

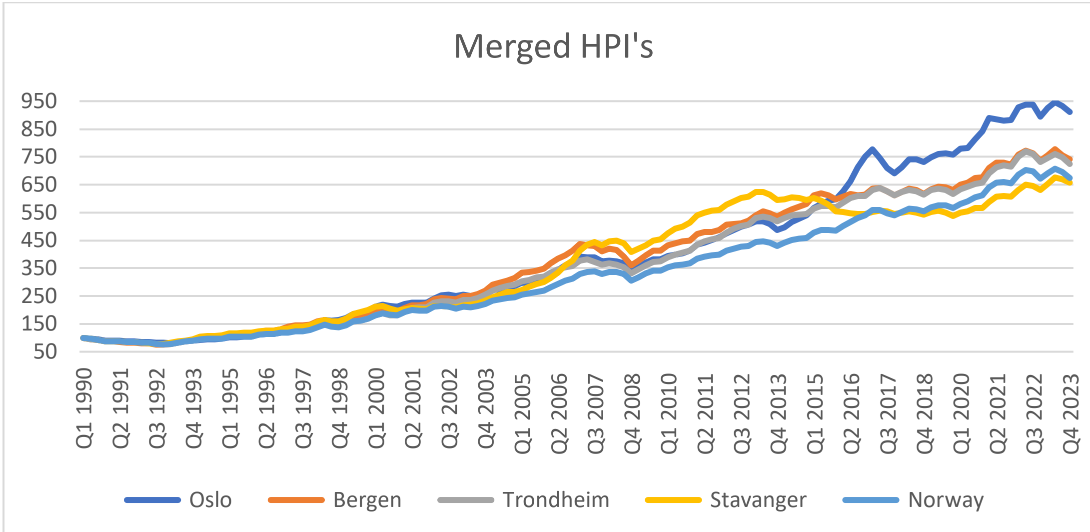
Figure 5: Comparison between The Real Estate Industry`s Housing Price Statistic and The Real Estate Industry`s HPI



Source: Finn.no, Eiendomsverdi, EFF, NEF and Eiendom Norge

Merging the two series gives us the following HPI's for Norway, Oslo, Bergen, Trondheim, and Stavanger:

Figure 6: Merged HPI`s



Source: Finn.no, Eiendomsverdi, and Eiendom Norge

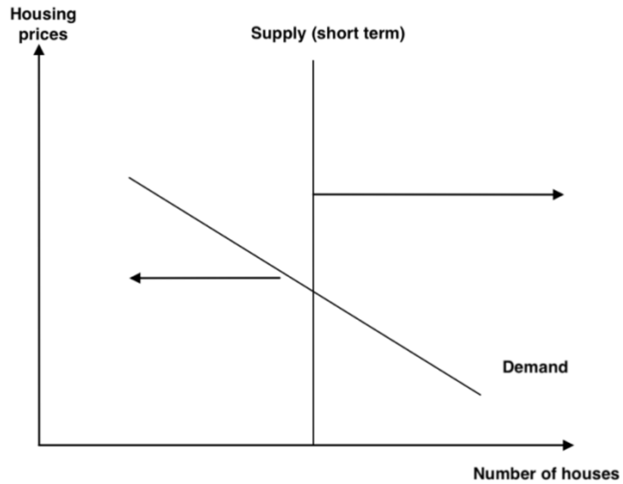
4.0 Theory

This chapter covers the theoretical foundations of the factors influencing housing prices, focusing on supply and demand dynamics, indicators of inflated prices, price-to-rent ratios, and the implications of a negative yield gap. Additionally, we explore the relationship between household debt and housing prices, comparing the returns on housing investments with alternative investment options. We also examine the relationship between commercial real estate and private housing, comparing price and rent levels between the two. By examining these elements, we aim to provide a comprehensive understanding of the various economic and financial forces at play in the Norwegian housing market, setting the stage for the empirical analysis that follows.

4.1 Supply and demand

Housing prices are influenced by both demand and supply factors. Housing demand can be categorized into two main components: demand for residential purposes and demand for housing as a pure investment. In the short term, fluctuations in housing prices are primarily driven by demand. This is due to the time required to plan, obtain permits, and construct new homes. Additionally, housing supply is localized, as it is reasonable to assume that most households are unwilling to relocate long distances solely for housing purposes. Furthermore, the annual rate of new construction is relatively low compared to the existing housing stock. Consequently, short-term models focus on the demand side of the housing market (Jacobsen & Naug, 2004), with key explanatory factors summarized as change in interest rates, expectations of growth, low costs etc.

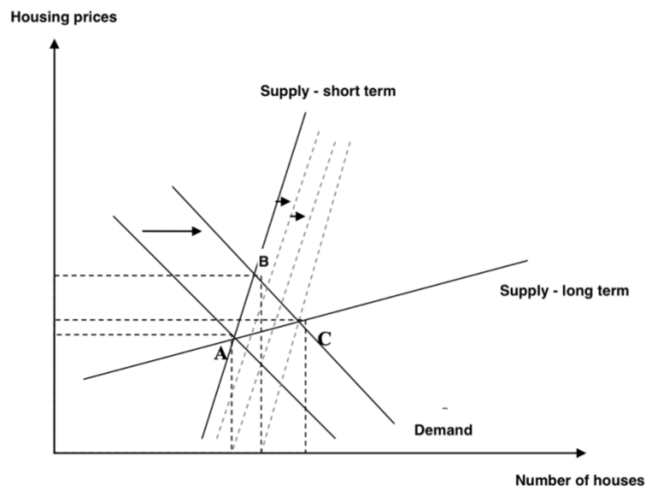
Figure 7: Short term changes in supply



The arrow pointing to the right illustrates factors that lead to increased demand and, consequently, higher prices in the short term, and vice versa. In the long term, the construction of new homes will align with demand, requiring consideration of the supply side as well (Jacobsen & Naug, 2004). An elevated level of housing investments beyond what is necessary for maintaining the existing housing stock results in an increased housing capital. Due to supply-side inertia[3], there may be scenarios where demand initially rises, prompting increased construction, but if demand subsequently falls, a decline in prices could be observed.

[3] Supply-side-inertia refers to the delayed response of housing supply to changes in demand due to the time required for planning, approval, and construction processes

Figure 8: Adjustment Between Demand and Supply in the Housing Market: Short-Term and Long-Term Perspectives

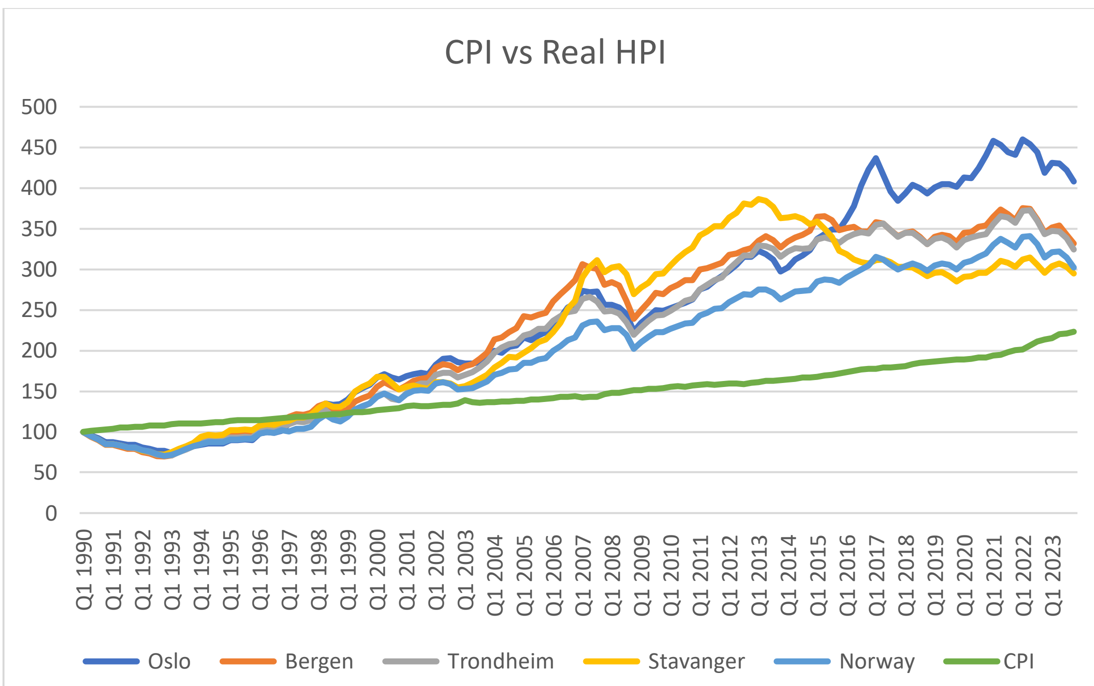


In Figure 8, the housing market is initially assumed to be in equilibrium at point A. Subsequently, an increase in demand leads to a new short-term adjustment at point B, where the demand shifts but the supply can only adjust minimally in the short term. However, the rise in prices makes it profitable to build more houses, resulting in a gradual adjustment of supply, or as illustrated, repeated small shifts of the supply curve to the right. Over time, the adjustment reaches point C, where the supply is fully adapted to a long-term supply curve. The housing stock increases as long as prices remain above the long-term supply curve. As can be seen, prices rise significantly in the short term compared to the long term, as housing construction adjusts to demand. In the short term, housing prices may also deviate somewhat from fundamental values due to imperfect information in the housing market. Price decisions are largely determined through bilateral negotiations between buyer and seller. Even though these prices are made public, each house is unique, making price comparisons difficult. It may take time to form an opinion on the price level of a specific type of apartment in a particular area. Furthermore, the market turnover rate may be low, making it even more challenging to assess actual value.

4.2 Indicators for inflated prices

The most critical criteria when assessing whether a market is in a bubble is a substantial increase in housing prices. Grytten (2009) examines empirical indicators to determine if housing prices are in a bubble by using the real Housing Price Index (HPI). In his paper, he constructs an index from a deflated housing price index for all property types, with inflation measured by the CPI and the CPI adjusted for tax changes and energy goods (CPI-JAE). This index illustrates the development of housing prices relative to inflation. Grytten defines that market stability is indicated by long-term and steady growth in these ratios. If a clear increase in the real housing price index is observed over a given period, it means that housing prices are growing faster than inflation. Grytten argues this can be an indicator that we are in a housing price bubble. In the graphical illustration below, we have calculated the real prices of our merged HPI's:

Figure 9: CPI vs Real HPI (1990-2023)

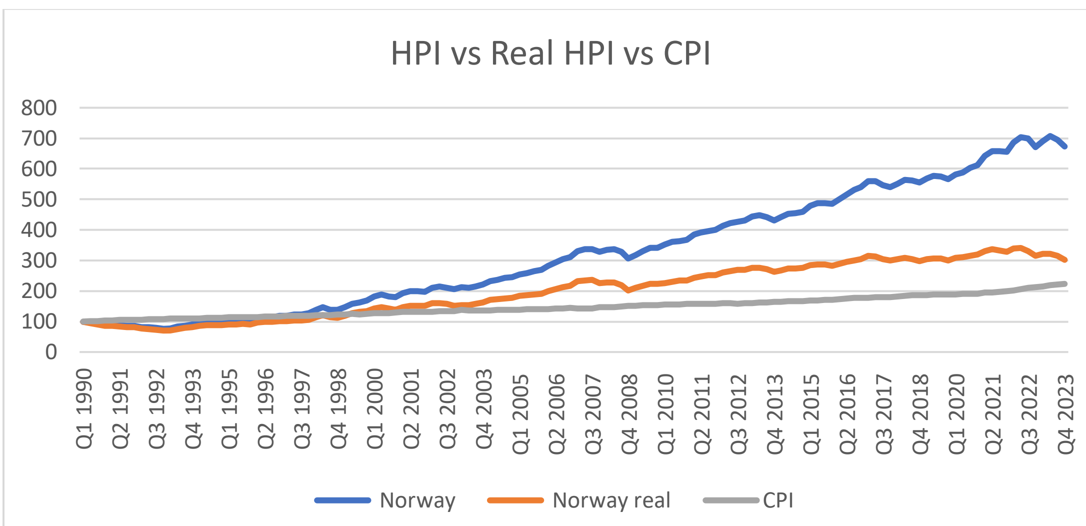


Source: SSB and Finn.no, Eiendomsverdi, EFF, NEF & Eiendom Norge

Figure 9 demonstrates that the real HPI's have increased at a faster rate than the CPI from 1990 to 2023. In comparison to the development in the CPI, it is evident that inflation-adjusted real estate prices have risen substantially. Over the illustrated period, the real HPI in Norway increased by 340% at its' peak in Q2 2022 compared to the CPI's increase of 107% in the same period, which is a significant difference considering that the CPI reflects the general price growth in the economy. Based on the differences presented in the figure, and Grytten's assumptions, it can be argued that we were in a housing price bubble up until Q2 2022, as the real housing prices for Norway, as of Q4 2023, have fallen 11.42% following the peak in Q2 2022. Over the same period, real housing price decreases in Oslo, Bergen, Trondheim, and Stavanger have been $-10.24\%, -11.47\%, -13.05\%$, and -6.31%, respectively. This goes to show that Norway, as well as its' four major cities, have experienced a significant decline in the real housing prices over the last 2 ½ years.

Despite the decline in the real HPI over the past couple of years, nominal housing prices continue to rise. As shown in Figure 10, both the HPI and the real HPI are growing at a faster rate than the CPI, suggesting that housing prices may still be overvalued, having increased excessively compared to the general price growth in the country.

Figure 10: HPI vs Real HPI vs CPI

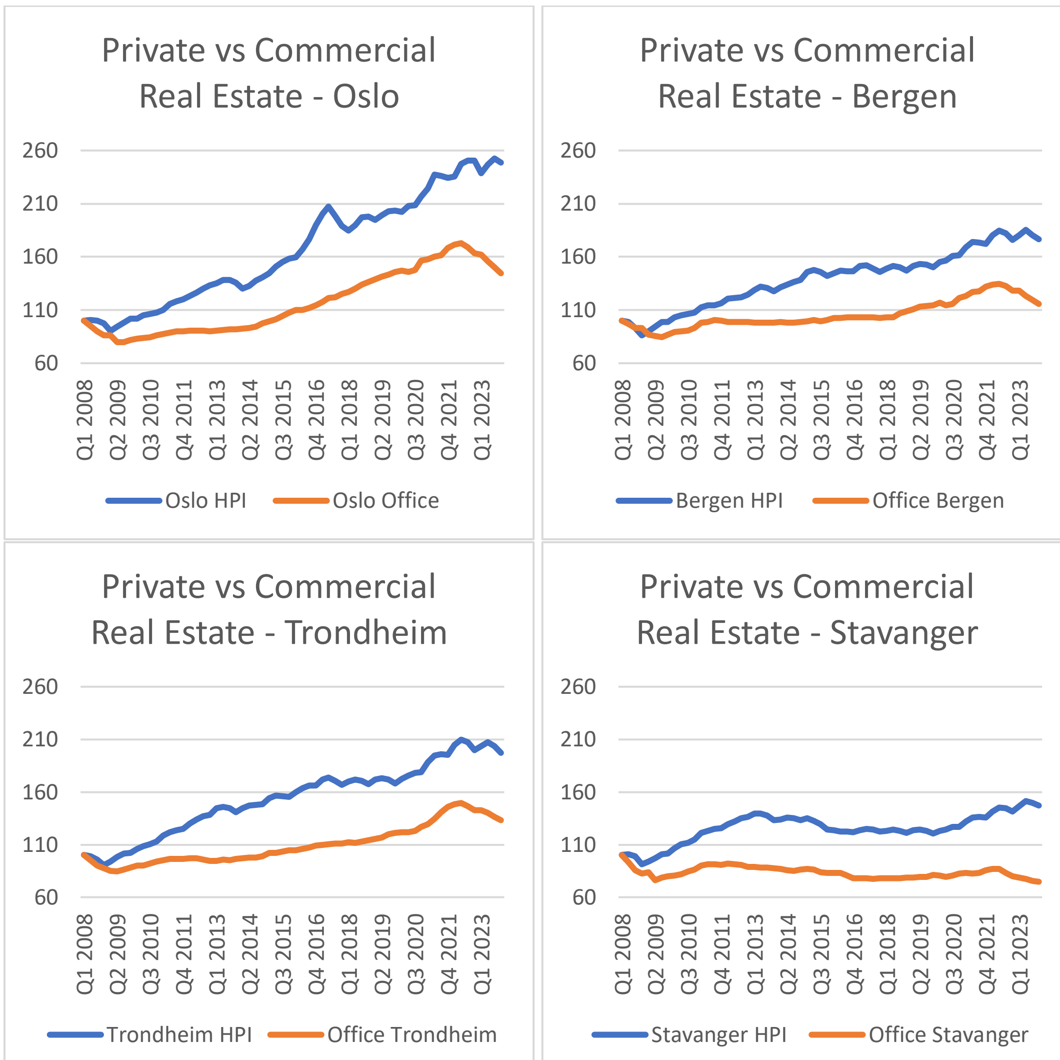


Source: SSB and Finn.no, Eiendomsverdi, EFF, NEF & Eiendom Norge

4.2.1 Commerical Real Estate vs. Private Housing Market

With such high increases in the private housing market, it is useful to compare the commercial property market to the private housing market to determine whether the price growth we’ve observed over the last decades is rational or not. Professional actors base their purchases on cash flows and yield requirements, emphasizing financial returns, whereas private market decisions are often influenced by emotions and personal preferences regarding living conditions. This comparison can provide insight into whether the price growth observed in the private housing market aligns with fundamental values or if it is driven by other factors.

Figure Series 1: Private vs Commercial real estate Q1 2008 – Q4 2023



Source: Newsec[4], Finn.no, Eiendomsverdi, EFF, NEF and Eiendom Norge

[4] Statistics on housing prices in the commercial real estate market were obtained from Newsec AS (Thunes & Dahl, personal communication, May 3, 2024). Newsec AS is Northern Europe’s largest valuer of commercial real estate.

As shown in Figure Series 1, prices in the private housing market have significantly exceeded those in the commercial real estate office segment over the past 16 years. In Oslo, the private market has increased by 141%, compared to a 45% growth in commercial real estate. In Bergen, the private market has risen by 76%, while commercial real estate has only increased by 15%. In Trondheim, the private market has grown by 97%, compared to a 33% increase in the office segment. In Stavanger, the private market has increased by 47%, whereas the office segment has decreased by 25%.

Furthermore, if we investigate the nominal price changes between the commercial real estate sector and the private housing market since the peak observed in Q2 2022, commercial prices have fallen $-16.30\%, -14.22\%$, -11.06%, and -14.17%, for Oslo Office, Bergen Office, Trondheim Office, and Stavanger Office, respectively. In the private housing market, prices have fallen $-3.00\%, -4.32\%$, and -6.03% for Oslo, Bergen, and Trondheim, while in Stavanger, prices have increased by 1.26%.

The disparities showcased above suggests that private housing prices could be overvalued compared to the commercial sector, which is typically comprised of more rational actors and investors. As mentioned earlier, professional actors base their purchases on cash flows and yield requirements, whereas private market decisions can in some scenarios be influenced by emotions and personal preferences. This could indicate that the growth we've observed in the private housing market may not be driven by fundamental factors, indicating that private housing prices may be overvalued. Particularly, the recent declines observed in the commercial sector over the past 2½ years could indicate that private housing prices may not have fallen sufficiently, indicating a potential for further correction in the private housing market.

4.3 P/R Coefficients

For many years, dividend and price/earnings methods have been essential in explaining stock prices. Essentially, these theories suggest that the value of a stock should be reflected by its discounted dividends. Poterba (1984) extended this principle to the real estate market by using rental prices as a stand-in for dividends.

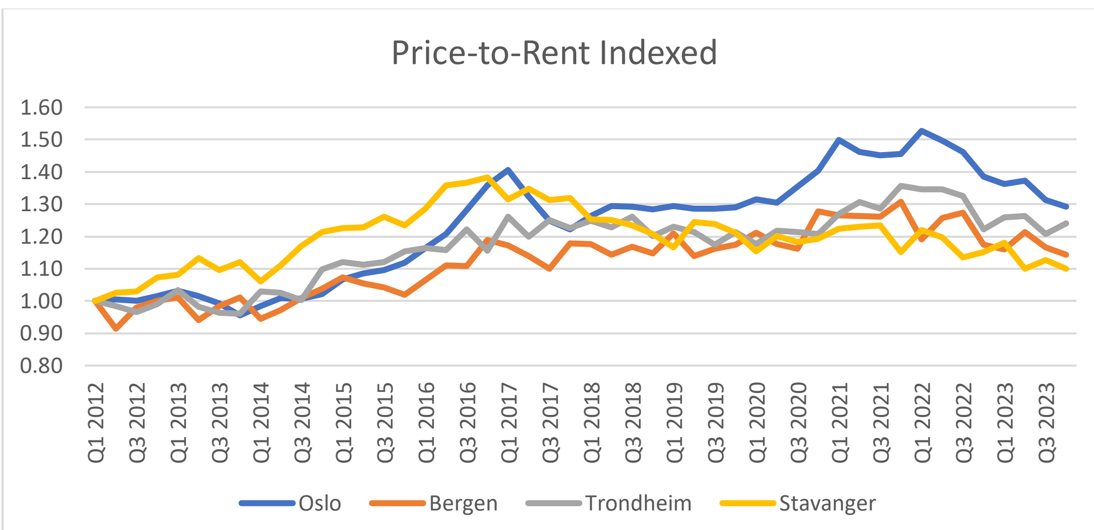
Rental income, as the future revenue generated by the property, should thus indicate the property's intrinsic value.

By comparing the ratio between sale prices (P) and rental prices (R), one can calculate $\frac{P}{R}$ coefficients. This ratio is a commonly used method to assess whether there is a housing bubble or overvaluation. The sale price reflects the market price of the property, and the annual rental income provides an estimate of what the property can earn in a year.

$$\frac{P}{R} = \frac{Property\ Price}{Rental\ Income}$$

It is generally assumed that this coefficient is relatively stable in the long term, but significant deviations can indicate potential market corrections. If property prices increase more than rental income, indicating significant short-term fluctuations, this can suggest potential imbalances in the market. According to Grytten (2009), this may indicate that the housing market is overvalued.

Figure 11: Price-to-Rent Indexed



Source: Eiendom Norge[5]

[5] Statistics on rent prices in the private housing market were obtained from Peder Eckblad Tollesrud, communications advisor at Eiendom Norge (Tollesrud, personal communication, April 10, 2024).

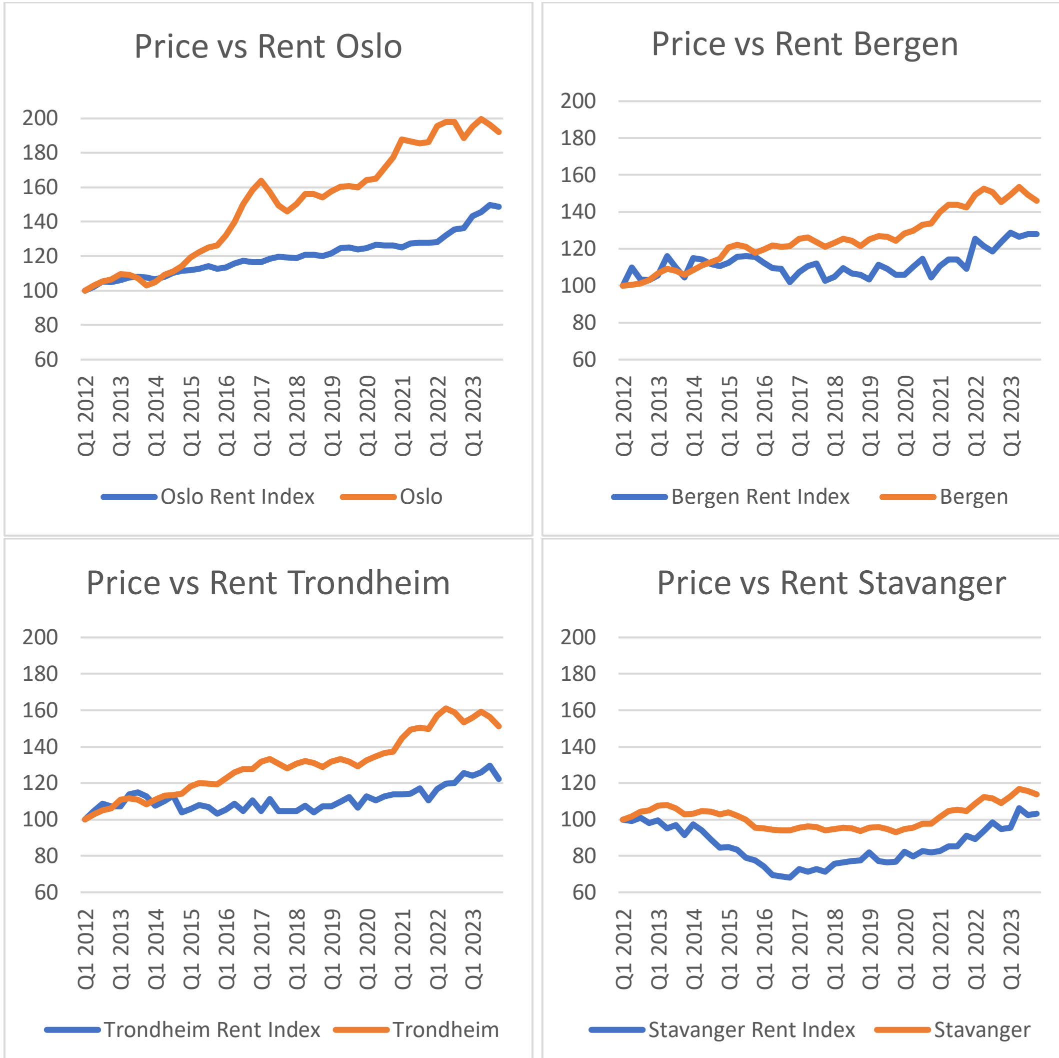
As shown in Figure 11, the housing prices in the Norwegian market have increased significantly more than rental prices over the last 12 years. The graph illustrates the development of the price-to-rent ratio for Oslo, Bergen, Trondheim, and Stavanger, with a base value of 1 for the P/R ratio in Q1 2012. All four cities show an upward trend in the price-to-rent ratio, indicating that housing prices have increased more rapidly than rental prices. The sharpest increase is observed in Oslo, where the price-to-rent ratio peaked in Q1 2022, while remaining elevated compared to the other cities. Bergen and Trondheim also show notable growth, although less pronounced, while Stavanger exhibits the least increase, reflecting a relatively more balanced growth between property prices and rental income.

According to Grytten (2009), this significant rise in the price-to-rent ratio suggests that the market could be in a bubble, where current prices do not represent fundamental values. Grytten also presents the idea that the market might be moving towards a new equilibrium, where other factors play a crucial role in determining housing prices. With a steady increase in housing prices since 1993, followed by a dip during the Financial Crisis in 2007-08, the Norwegian housing market has continued to rise over the last 15 years. Factors such as low interest rates, low inflation, and a construction market that is too slow to meet demand (Anundsen & Hov, 2023) lead us to question what truly defines equilibrium in the housing market. The graph clearly shows that the price-to-rent ratios in Norway's major cities have risen over the past decade, with Oslo experiencing the most significant increase. This trend, combined with the underlying economic conditions, suggests that the Norwegian housing market may be experiencing a bubble, where housing prices have increased excessively compared to rental prices.

4.3.1 Analysis of P/R in Oslo, Bergen, Trondheim, and Stavanger

To evaluate the stability of the Norwegian housing market, it is essential to continuously monitor the P/R ratios. A significantly high P/R ratio compared to historical averages may indicate a market bubble, where property prices are inflated beyond their real value. Conversely, a low P/R ratio might suggest undervaluation or an investment opportunity.

Figure Series 2: Price vs. Rent – Oslo, Bergen, Trondheim, and Stavanger



Source: Eiendom Norge

The analysis of housing price and rent indices from Q1 2012 to Q4 2023 for Oslo, Bergen, Trondheim, and Stavanger reveals a consistent upward trajectory in both metrics across all four cities. Notably, housing prices have escalated at a faster pace than rents, indicating a substantial disparity between these two indices. In Oslo, the pronounced increase in housing prices, particularly post-2015, suggests a heightened demand for property ownership relative to renting. Bergen exhibits some volatility in housing prices, especially after 2016, while rents have shown steady growth. Trondheim demonstrates a significant acceleration in housing prices beginning in 2016, with rents rising more gradually. Stavanger presents a distinctive pattern with a peak in housing prices around 2013, followed by a decline and subsequent recovery, with rent prices following this trend.

Although housing prices have outgrown rental prices in all four cities over the last 12 years, we do observe considerable differences in the extent of this gap. Indexed, the difference between housing prices and rental prices is 43 points in Oslo, 19 in Bergen, 29 in Trondheim, and 11 in Stavanger. Based on this, and following Grytten's theory of stable markets, this may indicate that the housing market in Oslo is overpriced. Trondheim also shows signs of overpricing, with a differential of 29 points.

4.3.2 Analysis of P/R in the Commercial Real Estate Sector

As with the private sector, it is also beneficial to look at the relationship between price and rent in the commercial sector. We discussed the considerable gap in price development between the private and commercial sectors in Figure Series 1 in Section 4.2.1. In this section, we investigate how the prices in commercial real estate have moved compared to the rent prices in the same sector.

Figure Series 3: Commercial Real Estate Price vs. Rent - Oslo, Bergen, Trondheim, and Stavanger

Source: Eiendom Norge and Arealstatistikk[6]

As shown in Figure Series 3, commercial real estate prices and rent prices appear to co-move to a much greater extent than in the private housing market. This may be due to the fact that the cash flow (rent) a property produces is directly linked to how a commercial real estate property is appraised and valued. Consequently, the gap observed in Figure Series 2 could indicate that the prices in the private housing market are deviating from fundamental values. Additionally, we observe that commercial real estate prices and rent prices exhibit a more rational pattern and tend

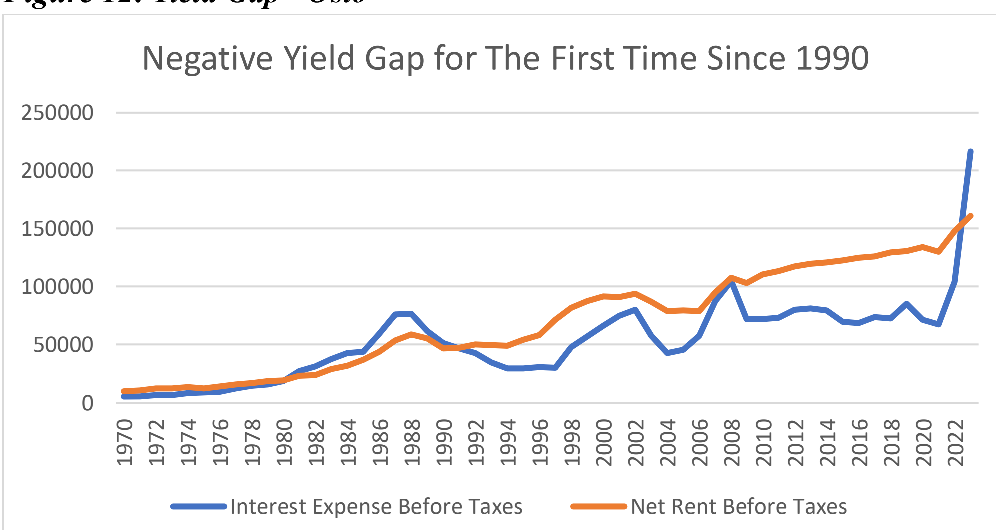
[6] Statistics on rent prices in the commercial real estate market were obtained from Sigmund Aas at Arealstatistikk AS (Aas, personal communication, April 15, 2024).

to converge over time. The outlier here is Stavanger, where prices in the office segment have decreased 25% over the last 12 years, while rent prices in the city have increased 38% over the same period. We observed that the development in prices and rents in the private housing market in Stavanger also deviated from the other cities to a great extent in Figure Series 2, indicating that there could be other factors driving the prices in Stavanger compared to Oslo, Bergen, and Trondheim.

4.4 Negative Yield Gap

Figure 12 illustrates the differences between net rent before tax and interest expenses before tax. For the first time since 1990, the cost of interest expenses before tax has exceeded the net rent income from leasing activities in Oslo. This can be considered serious, as it indicates that leasing out properties in the Norwegian capital is no longer profitable, leading to negative cash flows for property owners. From 2021 to 2023, rental prices have increased by 23%, while the cost of owning a property has surged by 220% (Oust, 2024). The substantial increase in property-related costs is primarily attributed to rising loan interest rates over the past two years, resulting in higher interest payments for property owners. Additionally, factors such as growing ownership costs, higher wealth taxation on secondary properties, insurance, municipal fees, and property taxes also play a significant role.

Figure 12: Yield Gap - Oslo



Source: Housing Market Researcher Are Oust, Professor at NTNU Business School & NRK

The sharp increase in costs related to owning property have influenced the number of secondary homes in Oslo, a rational reaction when rental properties are no longer profitable. While the number of secondary homes in Norway has decreased by 2% since Q3 2019, the decline in Oslo is much more pronounced, with a staggering 9.5% drop over the same period (Nef.no, 2023). The danger associated with this is that the supply of housing in major cities decreases while demand remains high. Based on supply and demand in the market, as discussed in Section 4.1, it can therefore be assumed that rental prices will continue to rise as long as the market for rental housing declines and the costs related to owning remain higher than the costs of renting. Based on these observations, one or more of the following three things would need to happen for the yield gap to become neutral or positive again:

1) **Housing prices fall**: If housing prices decrease, the cost of owning a home would become closer to the cost of renting, making homeownership more attractive.
2) **Interest rates are lowered**: Reducing interest rates would reduce the cost of borrowing, thereby reducing the overall cost of owning a home.
3) **Rental prices increase**: If rental prices increase, the cost of renting a home would become closer to the cost of owning, making renting less attractive compared to buying a home.

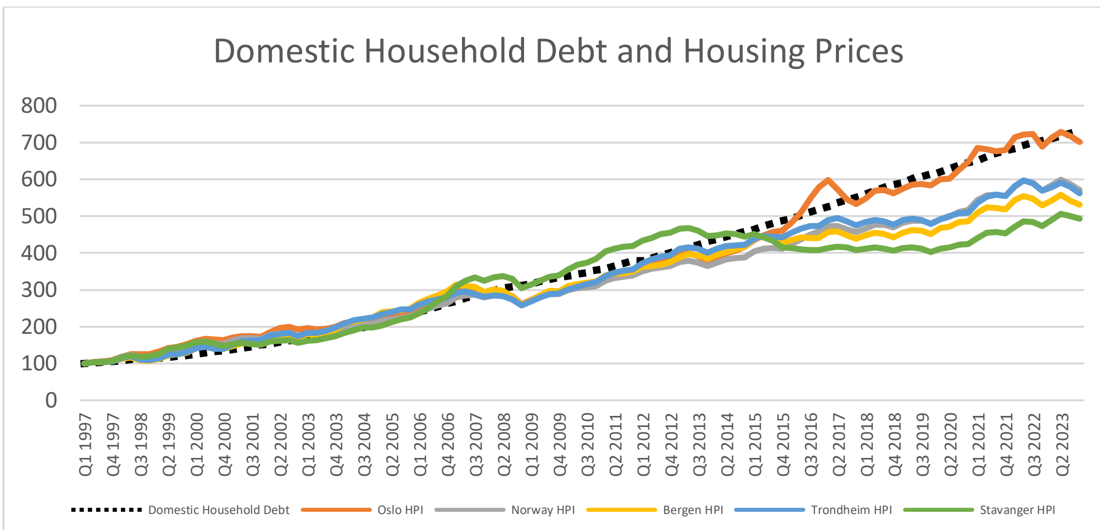
4.5 Domestic Household Debt and HPI

As previously mentioned, the cost of owning a home has significantly increased in recent years. The cost of owning escalates when interest rates are raised, and inflation amplifies this effect with increases in other property-related expenses as well. In the housing market, particularly in Norway, most purchases are financed through mortgages. Norwegian individuals are regulated by the “Boliglånsforskriften” (Regjeringen.no, 2024), which imposes a maximum debt limit per person, requiring a minimum of 15% equity and a maximum loan amount of five times their income.

With increasing housing prices, homeowners can refinance their homes to maximize loan capacity for increased borrowing capacity. In Figure 13, we observe the relationship between domestic household debt (dotted line) and housing prices in Norway, as well as its' four major cities, indexed with a base value of 100 from 1997 to 2023. The development of the HPI and domestic household debt trends similarly, although since the 2007-08 financial crisis, the HPI has slightly fallen behind overall growth in household debt.

Bank loans are the primary form of housing finance. Inspecting Figure 13, it appears that domestic household debt and housing prices co-move to a certain extent. This makes sense, as increased loan availability with rising prices could create a multiplier effect. Borgersen & Greibrokk explains that both static[7] and dynamic[8] multiplier effects can influence housing prices significantly (Borgersen & Greibrokk, 2005).

Figure 13: Domestic Household Debt and HPI



Source: SSB, Finn.no, Eiendomsverdi, EFF, NEF and Eiendom Norge

[7] The static multiplier effect refers to the immediate, direct impact of increased loan availability on housing prices, resulting in an immediate rise in demand and prices.
[8] The dynamic multiplier effect refers to the long-term, cumulative impact of increased loan availability on housing prices, where initial price increases lead to further borrowing and spending, amplifying the price increases over time.

4.6 Alternative Investments

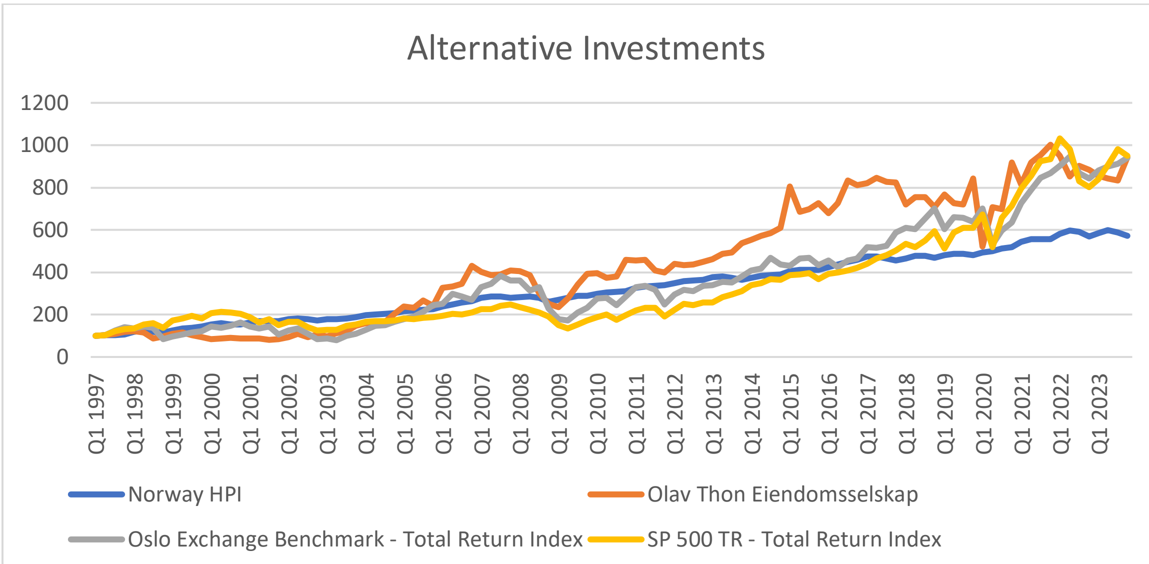
If we compare the Norwegian housing market to alternative investments, has it been more sensible to invest in stocks and other financial derivatives, or is the housing market as profitable as previously believed? As shown in Figure 14, the Norwegian HPI is compared with alternative investments over the period 1997 to 2023. At first glance, a maximum value for the Norway HPI in 2023 at a 470% return may appear poor compared to the other three, which all have had approximately 850% in returns. The other three alternative investments we have compared to the Norway HPI are:

- **Olav Thon Eiendomsselskap:** Olav Thon Eiendomsselskap is a leading real estate company in Norway, specializing in the ownership, development, and management of shopping centers and commercial properties. Its performance reflects the profitability and growth potential of the Norwegian commercial real estate market.
- **Oslo Exchange Benchmark – Total Return Index (OSEBX):** The OSEBX is a stock market index that tracks the performance of the largest and most traded stocks listed on the Oslo Stock Exchange. It represents the overall health and growth of the Norwegian stock market, including dividends reinvested.
- **S&P 500 – Total Return Index:** The S&P 500 Total Return Index measures the performance of the 500 largest publicly traded companies in the United States, including dividends reinvested. It serves as a broad indicator of the U.S. stock market's profitability and growth over time.

As mentioned in Section 4.5, the "Boliglånsforskriften," allows a gearing of 5 times income, with a 15% equity requirement for private property purchases (Regjeringen.no, 2024). This leverage can significantly enhance the returns on housing investments. For the Norway HPI to reach the same indexed level of 950 as Olav Thon Eiendomsselskap, OSEBX, and S&P 500, as shown in the graph, a gearing of 1.66 times the investment would be required. Given the allowed leverage of 5 times income, the potential return on investments in the housing market could be significantly amplified.

Considering the allowed leverage, the indexed price for the Norway HPI could theoretically reach about 2850, compared to the alternative investments' peak of about 950. This suggests a difference of approximately three times in maximum value from 1997 to 2023. This leverage effect indicates that, despite the seemingly lower returns of the Norway HPI, when factoring in the permitted gearing, housing investments can be highly competitive, potentially outperforming other investment options.

Figure 14: Alternative Investments Comparison



Source: LSEG Database.

In Table 2 below, we observe the maximum values for the HPI's of Norway, Oslo, Bergen, Trondheim, and Stavanger, indexed value from the period 1997-2023. The benchmark value they are compared to is the value of the Oslo Exchange Benchmark – Total Return Index (OSEBX), which has an indexed value of approximately 944 at the end of Q4 2023. The "Gearing Required" row represents the debt ratio required to achieve the same return as the OSEBX in the period from 1997 to 2023 for the housing prices in the different areas. Given that it is common to have a leverage of 5 times income, this is also included to represent the assumed maximum return in the given period if normal loan terms were used.

Table 2: HPI with Gearing compared to Alternative Investments

	Norway HPI	**Oslo HPI**	**Bergen HPI**	**Trondheim HPI**	**Stavanger HPI**
Indexed Value Q4 2023	570	700	531	561	492
Gearing Required	1,65	1,34	1,77	1,68	1,91
OSEBX Return	944	944	944	944	944
5x Gearing	2 852	3 503	2 655	2 806	2 463

As observed in the 'Gearing Required' row for the different regions, it requires at most only a 1.91 debt ratio to equalize the differences with the OSEBX, and as little as 1.34 in Oslo. The maximum potential return, if normal lending rules were considered, as shown in the '5x Gearing' row, would have been 3503 in Oslo, indexed from a starting value of 100 in 1997. This suggests that the maximum value of the Oslo HPI could be approximately three times that of the OSEBX from 1997 to 2023. It is important to note that this is under the assumption that the alternative investments, in this case the OSEBX, are not levered.

5.0 Literature review

In developing our research question, we conducted an extensive literature review, uncovering numerous studies crucial to our thesis. This section presents some of the most noteworthy studies, highlighting their methodologies, results, and conclusions. This literature search has been enlightening, deepening our understanding of the theoretical foundations of our topic.

We noted that while many studies align in their conclusions about the housing market, there are significant differences as well. This led us to explore a variety of studies for a comprehensive view of the topic. Analyzing these diverse studies is essential for a well-rounded understanding of housing market dynamics and how to apply the existing literature to our thesis.

5.1 Housing Bubble?

The article "*Housing Bubble*?" by Ola Grytten, published in May 2009 in Magma, delves into the historical context and empirical indicators of housing price bubbles, particularly in the light of the great financial crisis affecting various countries with substantial decreases in property values. Grytten explores whether Norway experienced a similar housing bubble that burst, given the drastic 14 percent drop in housing prices from August 2007 to December 2008. Interestingly, unlike in other countries, Norwegian housing prices rebounded early in 2009, raising questions about the unique characteristics of the Norwegian housing market.

Grytten defines financial bubbles as trading volumes at prices significantly deviating from fundamental values, suggesting that bubbles occur when prices are speculated to rise continually. Using historical data stretching back to 1819 from the Norwegian Central Bank's project on monetary history, Grytten evaluates the growth of housing prices over nearly two centuries. This long-term perspective highlights instances of potential bubbles and their aftermath, providing a robust framework for understanding the cyclic nature of housing markets.

The study employs various analytical methods to interpret housing price movements, including comparing housing prices to general price levels and rent prices, as well as calculating price-to-rent (P/R) coefficients. These coefficients help assess whether housing prices are in line with the income generated from property rentals, thus indicating overvaluation or potential bubbles. In discussing the modern era, Grytten points out the significant tripling of real housing prices from 1993 to 2007, describing this as potentially the largest bubble in Norwegian history. He suggests that the resilience of the Norwegian housing market in early 2009 might indicate that previous price drops were adjustments rather than signs of a sustained downturn.

This article is methodologically sound, employing historical data analysis and economic theory to dissect the dynamics of the housing market. It provides a detailed examination of the factors contributing to housing price fluctuations, including speculative behavior and economic policy impacts. Grytten's work contributes to the broader discourse on financial stability and real estate markets, offering valuable insights into the Norwegian property market.

5.2 Tax Subsidies to Owner-Occupied Housing: An Asset-Market Approach

The paper "*Tax Subsidies to Owner-Occupied Housing: An Asset-Market Approach*" by James M. Poterba, published in the November 1984 issue of The Quarterly Journal of Economics, examines the effects of inflation and tax policy on owner-occupied housing markets using an asset-market model. Poterba explores how the interaction of inflation rates and tax subsidies impacts house prices and the size of the housing capital stock.

This study is significant for its application of a detailed asset-market model that captures the complexities of the housing market dynamics, focusing on the interplay between economic variables like inflation and the regulatory environment of tax policy. Poterba provides empirical evidence suggesting that the tax deductions available to homeowners, when combined with inflation, contribute significantly to the rise in real house prices. For example, the accelerating inflation of the 1970s, by reducing homeowner's user costs, is shown to have potentially increased real house prices by up to 30%.

Methodologically, the paper is robust, utilizing simulations to estimate the long-term and short-term effects of changes in economic fundamentals on the housing market. The model predicts that shifts in inflation expectations can lead to substantial changes in house prices and construction activity, emphasizing the importance of considering future expectations in housing market analyses. Accordingly, we account for future expectations in our econometric analysis, constructing our own expectation indicator, which is explained in detail in Chapter 7 and 8.

5.3 What Drives Housing Prices?

The study "What Drives House Prices?" by Dag Henning Jacobsen and Bjørn E. Naug, published in the Economic Bulletin in 2004, presents a comprehensive analysis of the factors influencing house prices in Norway, particularly focusing on the period between 1990 and 2004. This study stands out for its methodical use of an empirical model to dissect the relationship between house prices and several fundamental economic indicators including interest rates, unemployment, total wage income, building mass, and a constructed expectation indicator.

Jacobsen and Naug meticulously examine the responsiveness of house prices to changes in economic fundamentals. They find that interest rates have a particularly strong influence, with house prices reacting significantly to shifts in this variable. Furthermore, the study explores the impact of unemployment on house prices, finding that unemployment is the second most influential factor. These findings underscore the complexity of the housing market, where multiple economic variables interact to influence price trends. The insights provided by Jacobsen and Naug suggest that both short-term and long-term factors need to be considered to understand and predict housing price movements.

The authors also delve into the potential for a housing bubble, querying whether current price levels are supported by underlying economic conditions. They accordingly assess the house prices with based on the fundamental variables in their model. Their findings suggest that while house prices have risen sharply, there is no conclusive evidence of a bubble, as price increases can largely be explained by the fundamental economic variables included in their model.

Moreover, Jacobsen and Naug's work is methodologically robust, employing a combination of statistical tests and model estimations to ensure the reliability of their results. This thorough approach allows them to draw meaningful conclusions about the drivers of house price dynamics and the potential risks of market instability.

In the upcoming chapters, we will perform an econometric analysis to better understand the determinants of housing prices in Norway and its four largest cities: Oslo, Bergen, Trondheim, and Stavanger. The model we use is a modified model based on the housing price model developed by Jacobsen & Naug in their 2004 analysis "What drives housing prices?". Here, we will investigate the impact of key economic variables such as income, bank's lending rates, unemployment, building permits, as well as the influence of Finans Norge's expectation barometer. By constructing and analyzing this model, we aim to provide a comprehensive understanding of the factors influencing housing prices in Norway, Oslo, Bergen, Trondheim, and Stavanger.

6.0 Methodology

This chapter details the methodologies used in our analysis. We apply Ordinary Least Squares (OLS) to estimate regression lines by minimizing residuals, ensuring validity through six key assumptions. Stationarity of time series data is tested using the Augmented Dickey-Fuller (ADF) test, with optimal lag lengths determined by the Schwarz Bayesian Information Criterion (SBIC). We explore cointegration to identify long-term relationships between non-stationary variables and use Error Correction Models (ECM) to capture both short-term dynamics and long-term equilibrium.

6.1 OLS

The fundamental method for finding the regression line that represents the relationship between variables is Ordinary Least Squares (OLS). OLS aims to find the linear combination of all observations that minimizes the total squared deviations from the regression line. The deviations from the regression line are the differences between the actual dependent variable y_t and the predicted variable $\hat{y}$, referred to as residuals u. The residuals are squared to prevent positive and negative deviations from canceling each other out (Stock & Watson, 2020). The model is given as:

$$(6.1) \quad Min \sum_{t=1}^{n}(\{y_t - \hat{y}\})^2 = \sum_{t=1}^{n}\left[y_t - \left(\beta_1 X_{1,t} + \beta_2 X_2 + \cdots + \beta_n X_{n,t}\right)\right]^2$$

6.1.1. OLS Assumptions

This section will present the six assumptions for OLS on time series data. If these assumptions hold, the coefficients and variance estimates are unbiased. An unbiased estimator has an expected value equal to the true parameter. The coefficients are the best linear unbiased estimators (BLUE), having the lowest variance, and are consistent, efficient, and unbiased. Additionally, the OLS coefficients are normally distributed, and t- and F-statistics follow their distributions, allowing for valid confidence intervals. The six assumptions, according to Wooldridge (2019), are:

MLR 1 - Linearity in Parameters

The model must be linear in parameters, meaning it can be expressed as:

$$(6.2) \quad y_t = \beta_0 + \beta_1 x_{t1} + \beta_2 x_{t2} + \cdots + \beta_k x_{tk} + u_t$$

Violating this assumption results in biased coefficients and unreliable standard errors.

MLR 2 – Random Sampling

We have a random sample of n observations:

$$(6.3) \quad \{(x_{t1}, x_{t2}, \ldots, x_{tk}, y_t): t = 1, \ldots, n\}$$

following the population model in MLR 1. This random sampling assumption implies that our data is suitable for estimating the coefficients β_j, and that the data has been selected to be representative of the population outlined in MLR 1.

MLR 3 - No Perfect Multicollinearity

None of the independent variables in the time series are constant or exact linear combinations of other independent variables. The assumption allows for strong correlation between explanatory variables but does not permit perfect correlation. In the presence of multicollinearity, the main concern is that it inflates the standard errors of the coefficient estimates. This reduced precision makes the estimates highly sensitive to changes in the data, potentially causing large fluctuations in coefficient values or changes in sign. However, it's important to note that the parameter estimates from OLS, in general, remain unbiased despite this lack of precision.

MLR 4 - Zero Conditional Mean

The expected value of the residuals must be zero for each time point t:

$$(6.4) \quad E(u_t|X) = 0,\ t = 1,2,\dots,n$$

Violations often result from omitted variables or measurement errors, leading to biased OLS coefficients.

MLR 5 - Homoscedasticity

The variance of the residuals must be constant for all values of the independent variable:

$$(6.5) \quad Var(u_t|X) = E(u_t^2|X) = \sigma^2,\ t = 1,2,\dots,n$$

Heteroscedasticity leads to biased coefficients and standard deviations.

MLR 6 - Normality

Residuals must be normally distributed:

$$(6.6) \quad u_t \sim Normal(0,\sigma^2)$$

Non-normal residuals lead to unreliable standard deviations and t- and F-tests. This is less of a problem with large sample sizes.

6.2 Stationarity

A fundamental requirement for analyzing time series data is that the processes involved are stationary. Stationarity means that the statistical properties of the process, such as its mean, variance, and autocorrelation structure, remain consistent over time. When a time series is non-stationary, applying standard statistical methods can lead to unreliable results.

In time series regression analysis, it is essential that the data is sufficiently stationary to accurately represent the relationship between dependent and independent variables across all time periods. A stochastic process, which is a collection of random variables representing the evolution of a system over time, is considered stationary if its joint probability distribution does not change when shifted in time.

Specifically, the stochastic process $\{x_t: t = 1,2, \ldots\}$ is stationary if for every collection of time indices $1 \leq t_1 < t_2 < \cdots < t_m$, the joint distribution of $\left(x_{t_1}, x_{t_2}, \ldots, x_{t_m}\right)$ is the same as the joint distribution of $\left(x_{t_1+h}, x_{t_2+h}, \ldots, x_{t_m+h}\right)$ for all integers $h \geq 1$ (Wooldridge, 2019, p. 367). To say that a time series x_t is stationary, the following conditions must be met:

$$(6.7) \quad E(x_t) = \mu$$

$$(6.8) \quad Var(x_t) = \sigma^2$$

$$(6.9) \quad Cov(x_t, x_{t+h}) = \rho$$

Many macroeconomic variables, however, do not satisfy these conditions and are therefore non-stationary. Non-stationary variables exhibit distributions that change over time, which can lead to misleading regression results or spurious regressions. Spurious regressions occur when a correlation is detected between two or more variables that are independent of each other. Such spurious correlations can happen in time series that share a common trend, causing unrelated variables appear to be correlated.

To address non-stationarity, a common approach is to difference the variables. Differencing transforms the series into the changes between periods rather than the absolute values. This method helps in stabilizing the mean of a time series by removing changes in the level of a time series, thus eliminating trends and seasonality. In our analysis in Chapter 8, we perform differencing on multiple variables to make them stationary. This is described in Section 8.1.

The first difference of a variable x_t is defined as $\Delta x_t = x_t - x_{t-1}$, where x_{t-1} is the value of x_t lagged by one period. If the series x_t becomes stationary after first differencing, it is said to be *integrated of order one* $I(1)$. A series that is stationary without differencing is *integrated of order zero* $I(0)$. If the variable is not stationarity after $I(1)$, we can test if it becomes stationarity after $I(2)$. Most economic variables become stationary after being integrated of first order, however.

6.2.1 Types of Non-Stationarity

We often divide between different types of non-stationary series. The time-series can be a pure random walk, a random walk with drift, or a deterministic trend.

A **pure random walk** is a time series where the current value is the previous value plus a random error term:

$$(6.10)\quad y_t = y_{t-1} + u_t$$

In this equation, u_t is a white noise error term[9] with a mean of zero and constant variance. This type of series lacks a deterministic trend and exhibits increasing variance over time, leading to non-stationarity.

A **random walk with drift** incorporates a constant term, indicating a systematic trend in one direction. It can be expressed as:

$$(6.11)\quad y_t = \alpha + y_{t-1} + u_t$$

In this equation, α represents the drift term. α introduces a linear trend, making the series non-stationary because both the mean and variance change over time.

A **deterministic trend** series includes a predictable component, typically a linear or quadratic trend, without the stochastic random walk component. It can be expressed as:

$$(6.12)\quad y_t = \alpha + \beta t + u_t$$

In this model, βt describes the deterministic trend. Although u_t might be stationary, the overall series remains non-stationary due to the deterministic trend component.

[9] A white noise error term is a random variable with a mean of zero, constant variance, and no autocorrelation, implying that it is uncorrelated with all other terms in the series.

Understanding the distinctions between these three is crucial for being able to apply the proper techniques to achieve stationarity. We discuss how we deal with this in Section 6.3 and Section 8.1 "Stationarity Results". In our Augmented Dickey-Fuller test presented in Section 8.1, we test for a random walk with drift and for a deterministic trend, as described above.

6.3 Testing for Stationarity

The Dickey-Fuller (DF) test is used to determine whether a series has a unit root, implying it is non-stationary. Wooldridge (2019) explains that the simplest approach to testing for a unit root begins with an AR(1) model:

$$(6.13)\quad y_t = \alpha + \rho y_{t-1} + u_t, t = 1,2, \ldots,$$

Where y_0 is the observed initial value:

$$(6.14)\quad E(u_t | y_{t-1}, y_{t-2}, \ldots, y_0) = 0$$

If y_t follows equation (6.13), it has a unit root if $\rho = 1$. If $\alpha = 0$ and $\rho = 1$, y_t follows a random walk without drift. If $\alpha \neq 0$ and $\rho = 1$, y_t is a random walk with drift. This would mean that $E(y_t)$ is a linear function of t.

We usually leave α unspecified under the null hypothesis. The null hypothesis is that y_t has a unit root with the alternative hypothesis that y_t is stationary:

$$(6.15)\quad H_0: \rho = 1$$
$$(6.16)\quad H_1:\ \rho < 1$$

If we fail to reject the null hypothesis of a unit root, this indicates that the series has a unit root and is non-stationary. If we reject the null hypothesis, the alternative hypothesis is accepted, and we can conclude that the series is stationary. Also note that $\rho > 1$ is not usually considered, as this would imply that y_t is explosive.

A normal way to carry out the unit root test is to take the first difference, as discussed in Section 6.2. We subtract y_{t-1} from both sides of equation (6.13), as follows:

$$(6.17)\quad \Delta y_t = \alpha + (\rho - 1)y_{t-1} + u_t$$

In the Dickey-Fuller test, we assume that the error term is white noise. However, this assumption often does not hold in practice because residuals from time-series data can exhibit autocorrelation. When residuals are autocorrelated, the standard Dickey-Fuller test may be invalid, as it relies on the assumption of white noise errors. This issue can lead to incorrect conclusions about the presence of a unit root in the series.

To address this problem, the Augmented Dickey-Fuller (ADF) test extends the basic Dickey-Fuller test by including lagged differences of the variables to capture the autocorrelation in the residuals. The ADF test equation is:

$$(6.18)\quad \Delta y_t = \alpha + \beta t + \rho y_{t-1} + \sum_{i=1}^{p} \delta_i \, \Delta y_{t-i} + u_t$$

Where Δy_t is the first difference of the series, α is a constant, β represents the deterministic trend component, ρ is the coefficient being tested to determine if the series has a unit root, $\sum_{i=1}^{p} \delta_i \, \Delta y_{t-i}$ represents the sum of the lagged variables up to p lags, and u_t is the error term, which is assumed to be white noise.

In Chapter 7, we introduce all the variables included in our housing models. We test these variables for stationarity using the Augmented Dickey-Fuller test, as non-stationary variables can result in spurious regression outcomes. The results of the ADF test are presented in Table 4 in Section 8.1. Our findings indicate that several variables are non-stationary, necessitating the use of techniques like first differencing to achieve stationarity, as explained in Section 6.2.

6.3.1 Information Criteria

Selecting the optimal number of lags to include in the Augmented Dickey-Fuller test is crucial to ensure the validity and efficiency of the model. How many lags to include can be done in two ways; looking at how many lags are significant based on the student t-statistic, or we can use information criterions, such as the Akaike Information Criterion (AIC) and Schwarz Bayesian Information Criterion (SBIC).

The object is to choose the number of lags that minimizes the value of the information criteria.

According to Brooks (2019), SBIC is strongly consistent (but inefficient) and AIC is not consistent, but generally more efficient (Brooks, 2019, p. 361). SBIC is normally preferred for larger samples, as it imposes a stronger penalty for the number of parameters in the model. We employ the SBIC when selecting the optimal lag length in Section 8.1. SBIC is given by:

$$(6.19)\quad SBIC = \ln(\hat{\sigma}^2) + \frac{k}{T}\ln T$$

Where $\ln(\hat{\sigma}^2)$ is the log of the estimated variance of the residuals, K is the number of parameters, and T is the sample size.

6.4 Autocorrelation

When the variance in a time series changes over time, it is referred to as heteroskedasticity. This condition complicates the calculation of standard errors for the coefficients, making hypothesis testing unreliable. Heteroskedasticity also violates MLR 5 in the OLS assumptions. In contrast, a time series with constant variance is called homoskedasticity. Heteroskedasticity can be either conditional or unconditional. Conditional heteroskedasticity occurs when future variance changes are unpredictable. Conversely, unconditional heteroskedasticity happens when future variance changes can be anticipated, often due to seasonal patterns.

A more significant issue than heteroskedasticity is the correlation between error terms at different points in time, known as serial correlation or autocorrelation. Several factors can cause both autocorrelation and heteroskedasticity. Often, the dependent variable is influenced by independent variables that were not included in the regression model, also known as omitted variable bias. Subsequently, the characteristics of the dependent variable that should have been explained by these omitted variables end up in the error term instead. To test for autocorrelation, various tests can be applied.

6.4.1 Durbin-Watson

To examine whether a time series has autocorrelation in the error term, the Durbin-Watson test can be applied. This test is a statistical method used to test for first order autocorrelation. In other words, a test for whether a (residual) series is related to its immediately preceding values (Brooks, 2019, p. 270). The Durbin-Watson (DW) statistic is calculated as follows:

$$(6.20)\quad DW = \frac{\sum_{t=2}^{T}(\hat{u}_t - \hat{u}_{t-1})^2}{\sum_{t=2}^{T}\hat{u}_t^2}$$

Where $\hat{u}$ is the residual at time t, $\hat{u}_{t-1}$ is the residual at time $t-1$, and T represents the total number of observations.

The numerator, $\sum_{t=2}^{T}(\hat{u}_t - \hat{u}_{t-1})^2$, measures the sum of the squared differences between successive residuals. This captures the degree to which the residuals change from one time period to the next, which is indicative of autocorrelation. The denominator, $\sum_{t=2}^{T}\hat{u}_t^2$, represents the total sum of squared residuals, which serves to normalize the numerator.

The values of the DW statistic ranges from 0-4, where:

- A value near 2 suggests no autocorrelation
- A value closer to 0 indicates positive autocorrelation
- A value closer to 4 indicates negative autocorrelation

The Durbin-Watson test is primarily useful for detecting first-order autocorrelation in the residuals of a regression model. However, it falls short when higher-order autocorrelations are present or when the model includes lagged dependent variables. If the test is used in the presence of lags of the dependent variable or otherwise stochastic variables, the test statistic would be biased towards 2, suggesting that in some instances the null hypothesis of no autocorrelation would not be rejected when it should be (Brooks, p. 274, 2019). In our housing models presented Chapter 8, we include lagged variables, rendering the Durbin Watson test inapplicable.

To address these limitations, we later employ the Ljung-Box test, which generalizes the Durbin-Watson test to detect higher-order autocorrelations and handles lagged variables more effectively.

6.4.2 Ljung-Box

To examine whether a time series exhibits autocorrelation across multiple lags, the Ljung-Box test can be applied. This test is a statistical method used to assess the overall randomness of residuals in a time series model. Unlike the Durbin-Watson test, which focuses solely on first-order autocorrelation, the Ljung-Box test evaluates the presence of autocorrelation at multiple lag intervals. The Ljung-Box (Q) statistic is calculated as follows:

$$(6.21)\quad Q^* = T(T + 2)\sum_{k=1}^{m}\frac{\hat{r}_k^2}{T-k}$$

Where T is the total number of observations, $\hat{r}_k^2$ is the sample autocorrelation at lag k, and m is the number of lags being tested.

In this formula, the term $\frac{T(T+2)}{T-k}$ is a scaling factor that adjusts the sum of squared sample autocorrelations to account for the number of observations and the lag being considered.

The null hypothesis H_0 for the Ljung-Box test is that the residuals are independently distributed (no autocorrelation) up to the specified number of lags. The alternative hypothesis H_1 is that autocorrelation exists among the residuals up to the specified number of lags. The Ljung-Box statistic follows a chi-squared distribution (χ^2) with m degrees of freedom. Therefore, the decision rule is based on comparing the calculated Q statistic to the critical value from the chi-squared distribution (χ^2). If the Q statistic exceeds the critical value, the null hypothesis of no autocorrelation is rejected. We further describe how we incorporate the Ljung-Box test to test for autocorrelation in our models in Section 8.5.

6.5 Cointegration

In time series analysis, cointegration refers to the long-term equilibrium relationship between two or more non-stationary variables. Although individual variables may be non-stationary, their linear combination can be stationary. This implies that while the individual variables might deviate from one another in the short run, there exists a stable, long-term relationship between them. Assume that we have two non-stationary series x_t and y_t which are integrated of first order $I(1)$. If the linear combination of x_t and y_t gives $I(0)$, we can conclude that x_t and y_t are cointegrated. Identifying such relationships is essential in econometrics because it allows for the modeling of meaningful long-term connections between economic variables, thereby avoiding misleading results that can arise from spurious regressions (Stock & Watson, 2020).

6.5.1 Testing for Cointegration

To test for cointegration, we can use methods like the Engle-Granger and Johansen tests. The Engle-Granger method estimates a long-run relationship using Ordinary Least Squares and tests the residuals for stationarity with a unit root test; if stationary, the variables are cointegrated (Engle & Granger, 1987). The Johansen test is more comprehensive, handling multiple variables and determining the number of cointegrating relationships using a vector autoregressive (VAR) model (Johansen, 1988). However, this method is more complex. In her 2007 analysis, Fredriksen found that Jacobsen & Naug (2004) used a one-step estimation method when constructing their housing price model (Fredriksen, 2007). We will therefore employ a one-step estimation in our modified housing price model. One-step estimation is covered in Section 6.6.1.

6.6 Error Correction Model

Error correction models (ECMs) are used to capture both short-term dynamics and long-term equilibrium relationships between time-series variables. This approach is particularly useful for our analysis, as it allows us to examine how our variables describe housing prices in both the short run and the long run. As discussed earlier, to obtain meaningful results from an ECM, the variables must be cointegrated. We begin by assuming that there is a long-term equilibrium between two variables, X and Y:

$$(6.22) \quad Y_t = AX_t^{\beta_1}$$

Where A and β_1 are constant. β_1 is the long-term elasticity with respect to X. If we say that small letters indicate that the variable is in logarithmic form, we can write:

$$(6.23)\quad y_t = \beta_0^* + \beta_1 x_t$$

Where $\beta_0^* = \ln(A)$.

If x remains at a constant level z for an extended period, y will converge towards the value $\beta_0^* + \beta_1 z$. This allows us to define the extent of disequilibrium (ED_t).

$$(6.24)\quad ED_t = y_t - \beta_0^* + \beta_1 x_t$$

If y and x have a long-term equilibrium relationship, $ED_t = 0$ has to hold. Since this is rarely the case, it's normal to included lagged values of x and y in a short-term model:

$$(6.25)\quad y_t = b_0 + b_1 x_t + b_2 x_{t-1} + (1-\mu) y_{t-1} + u_t$$

This can be rewritten as:

$$(6.26)\quad \Delta y_t = b_0 + b_1 \Delta x_t + (b_1 + b_2) x_{t-1} - \lambda y_{t-1} + u_t$$

Where $\lambda = 1 - \mu$

We can then add a new parameter β_1, which is defined as $\beta_1 = \frac{b_1+b_2}{\lambda}$.

This then gives us the equation:

$$(6.27)\quad \Delta y_t = b_1 \Delta x_t - \lambda(y_{t-1} - \beta_0 - \beta_1 x_{t-1}) + u_t$$

Where $\beta_0 = \frac{b_0}{\lambda}$ is a new parameter.

β_0 and β_1 are long-term parameters, while b_1 and λ are short-term parameters, where b_1 measures the effect a one unit increase in x on y in the short term. The λ (error correction parameter) estimates the speed of return to equilibrium after a deviation from the equilibrium after a deviation from the equilibrium between y and x. In order for the model to return to equilibrium, λ must lie between 0 and 1. What this means is that if the λ has a value of < 0, there is no long-term equilibrium relationship between x and y. β_1 measures the long-term effect one unit increase in x has on y.

This future effect will be distributed over future time-periods according to the error correction parameter (λ).

In Section 8.3, we explain how we construct our ECM, and which variables we include in the short run and long run estimations. We also interpret the error correction parameter (λ) in Section 8.6.1, to investigate whether there exists a long-term equilibrium relationship. We also calculate the adjustment speed back to equilibrium in the same section. Applying an ECM allows us to better understand the dynamic adjustments and long-term relationships between the variables, providing a more comprehensive analysis of the factors influencing housing prices in Norway and its major cities.

6.6.1 One-step estimation

The ECM in equation (6.27) can be estimated using OLS. The error correction model can be estimated in one step. We will put this equation to use when we construct our ECMs in Section 7.6.1 and Section 8.3. If we multiply out equation (6.27), we get the following expanded form:

$$(6.28)\quad = b_1 \Delta x_t - \lambda y_{t-1} + \lambda \beta_1 x_{t-1} + u_t$$

$$= \boldsymbol{a + b\Delta x_t + c y_{t-1} + d x_{t-1} + u_t}$$

Where:

$a = \lambda\beta_0,\ b = b_1,\ c = -\lambda$, and $d = \lambda\beta_1$

Hence, if we run a regression with OLS of Δy_t on Δx_t, y_{t-1}, and x_{t-1}, this will give us estimates for a, b, c, and d. We use these estimates to interpret the ECM in Section 8.3.

Since $c = -\lambda$, we can rearrange the equation to get $\lambda = -c$. Hence, we can see that $\beta_0 = \frac{-a}{c}$ and $\beta_1 = \frac{-d}{c}$. As mentioned earlier, β_0 and β_1 are long term parameters, and c is the error correction parameter.

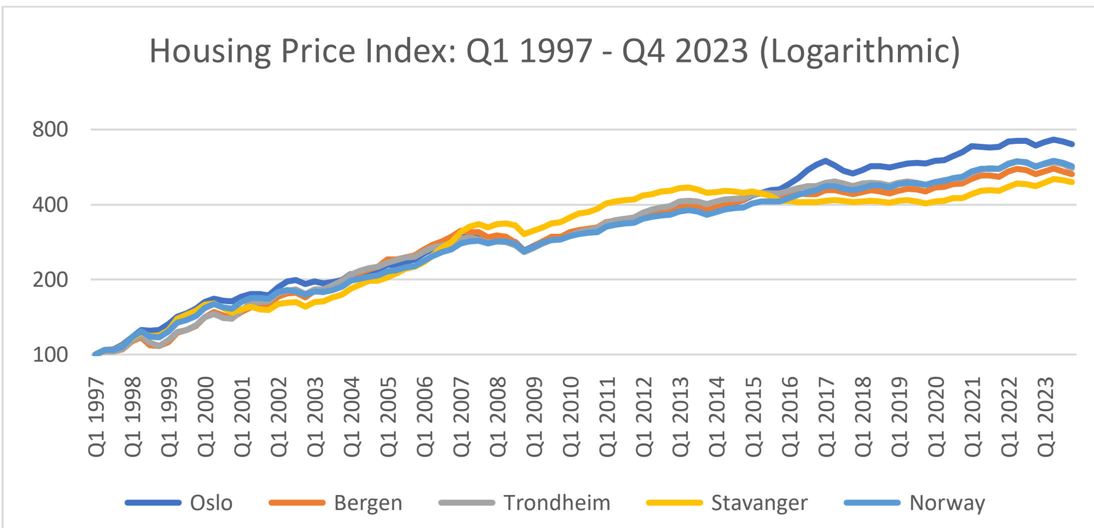
7.0 Data

This chapter describes all the data we employ in our econometric analysis to estimate five separate models for the housing prices in Norway, Oslo, Bergen, Trondheim, and Stavanger. All the data presented in this chapter covers the period from Q1 1997 to Q4 2023. This comprehensive time frame allows for an in-depth analysis of housing price trends and economic factors affecting the Norwegian housing market over more than two decades.

7.1 Housing Prices

We use the constructed housing price indices we constructed in Chapter 3 as the dependent variables in our five models. The following figure shows the constructed logarithmic housing price index for the observation period we employ in our analysis:

Figure 15: HPI Norway, Oslo, Bergen, Trondheim, and Stavanger (Logarithmic)



Source: Finn.no, Eiendomsverdi, EFF, NEF, and Eiendom Norge

The indexed time-series all start at a base value of 100 in Q1 1997. Subsequently, we are only interested in examining the development in housing prices for the exact period covered in our analyses. The housing price index is also presented in nominal values, meaning that we have not adjusted it for inflation. The HPI's are also expressed in logarithmic form, as this allows for a better understanding of the growth rates and makes the data more suitable for econometric modeling.

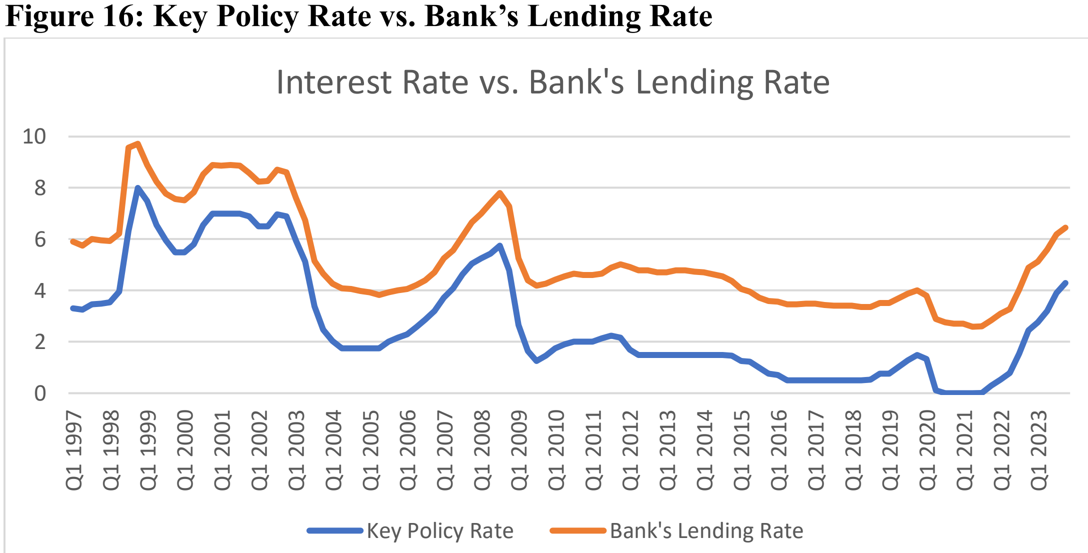
7.2 Bank's Lending Rate

According to Jacobsen & Naug (2004), interest rates are among the most important and significant fundamental economic variable when it comes to what drives housing prices. However, consumers, and investors alike, are not able to borrow at the key policy rate set by the Norwegian Central Bank. Therefore, we use the Bank's Lending Rate as the proxy for the interest rate in our analysis.

The bank's lending rate directly affects the cost of borrowing for both consumers and investors. Changes in this rate influence mortgage rates, which in turn impact housing affordability and demand. When lending rates are low, borrowing costs decrease, making it easier to finance home purchases. Conversely, higher lending rates increase borrowing costs. Therefore, using the bank's lending rate as a proxy in our analysis helps us better understand the relationship between interest rates and housing prices.

The data for the bank's lending rate is obtained from SSB's StatBank table 07200, and the data for the key policy rate is obtained from Norges Bank. In Norway, as of Q4 2023, the percentage of variable-rate loans to fixed-rate loans given out by banks are 94.5% to 5.5%, respectively (SSB, 2024). It is therefore safe to assume that changes in the interest rate will have almost an immediate impact on borrowers. Below is a graphical illustration of the nominal bank's lending rate compared to the key policy rate set by the Norwegian Central Bank:

Figure 16: Key Policy Rate vs. Bank's Lending Rate



Source: Norges Bank and SSB

When computing the effect of the bank's lending rate, Jacobsen & Naug (2004) also accounted for the impact of the marginal tax rate on capital income and capital expenses. This is done by subtracting the marginal tax rate from the bank's lending rate. This approach aligns with what we discussed in Chapter 5, where Poterba (1984), emphasizes the importance of considering tax policies when evaluating the effective cost of borrowing. Poterba highlights that tax deductions on mortgage interest can significantly reduce the net cost of borrowing, thereby influencing housing prices by making homeownership more affordable.

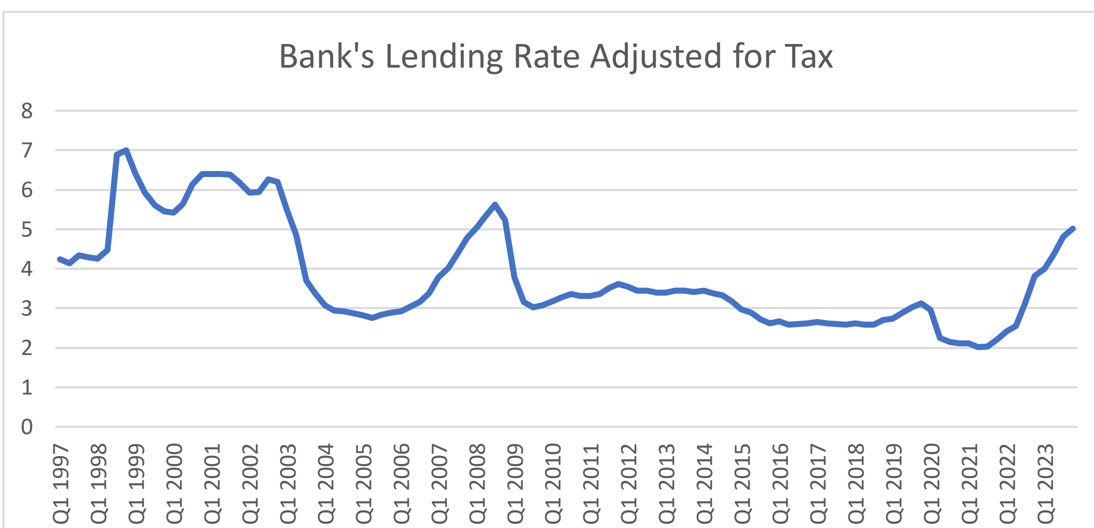
Table 3: Marginal Tax Rate in Norway 1997-2023

Year	Marginal Tax Rate	$(1 - T)$
1997-2013	28%	0.72
2014-2015	27%	0.73
2016	25%	0.75
2017	24%	0.76
2018	23%	0.77
2019-2023	22%	0.78

Source: TradingEconomics.com

After subtracting the marginal tax rate from the bank's lending rate, we get the rate represented graphically in Figure 17, which we apply in the models in our analysis.

Figure 17: Bank's Lending Rate Adjusted for Marginal Tax Rate in Norway



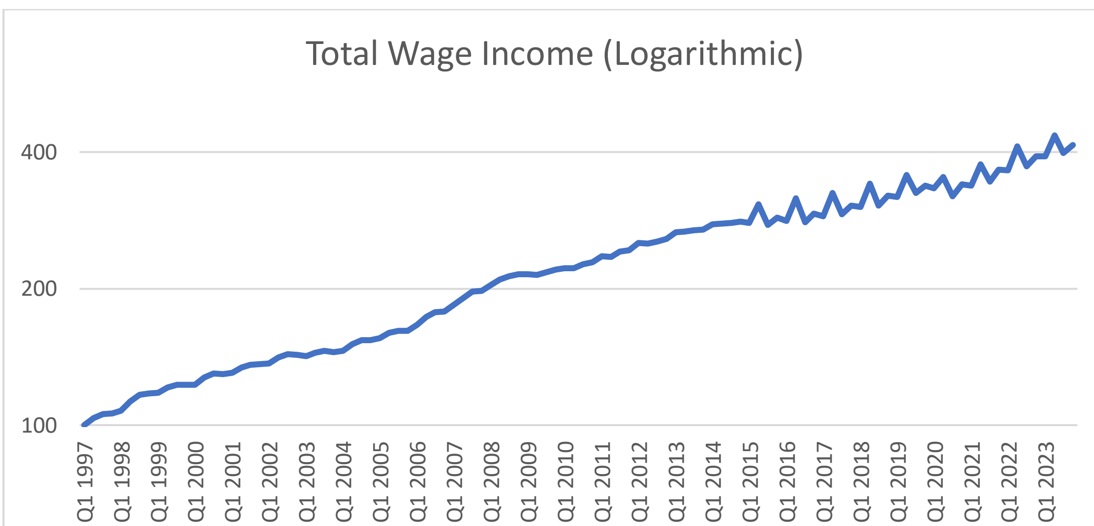
Source: SSB

7.3 Income

Income is another variable that directly affects consumers ability to take up loans. The bigger your income, the more debt you are able to take on. In their analysis, Jacobsen & Naug (2004) found that housing prices will grow approximately in line with wage income in the long term. Thus, stronger growth in wage incomes could contribute to further increasing housing prices.

The data for the total wage income in the economy is obtained from SSB, Table 09175. There does exist data on income for the four cities going back to 2000. However, this is in annual, and not quarterly terms. Neither does it cover the time-period of our analysis, which goes back to Q1 1997. Therefore, we use the quarterly total wage income in Norway for all our models later in the analysis. As with the HPI's in Section 7.1, we express the total wage income in logarithmic form in our models. This is because log transformations help stabilize the variance and provides a clearer interpretation of the growth rates. Below is a graphical representation of the indexed logarithmic total wage income:

Figure 18: Total Wage Income in the Norwegian Economy (Logarithmic)



Source: SSB

Since 2015, there have been notable increases in the second quarter of each year. The implementation of the "A-melding" on January 1, 2015, introduced a new reporting system for businesses to the Tax Administration, NAV, and SSB, consolidating five previous data deliveries into one. Consequently, since 2015, wage data reflects payments as they are disbursed. According to Gimling, the Q2 spike can largely be attributed to holiday pay[10], which is typically paid out in June (Gimling, personal communication, June 19, 2024)[11]. Before 2015, wage components were recorded more evenly over time, resulting in a smoother line pre-2015, as observed graphically in Figure 18. The transition to the "A-melding" and the new recording principle led to the observed seasonal pattern change from 2015 onwards.

7.4 Unemployment

Unemployment provides significant insight into the health of the economy. In Norway, unemployment is measured using two main approaches: the Labor Force Survey (AKU) by SSB and data from the Norwegian Labor and Welfare Administration (NAV). The AKU includes individuals actively seeking work, even if not registered with employment agencies, and usually reports higher figures. On the other hand, NAV tracks registered unemployed individuals, often reporting lower numbers. The figures in both statistics are reported as a percentage of the labor force, which includes both employed individuals and those registered as completely unemployed.

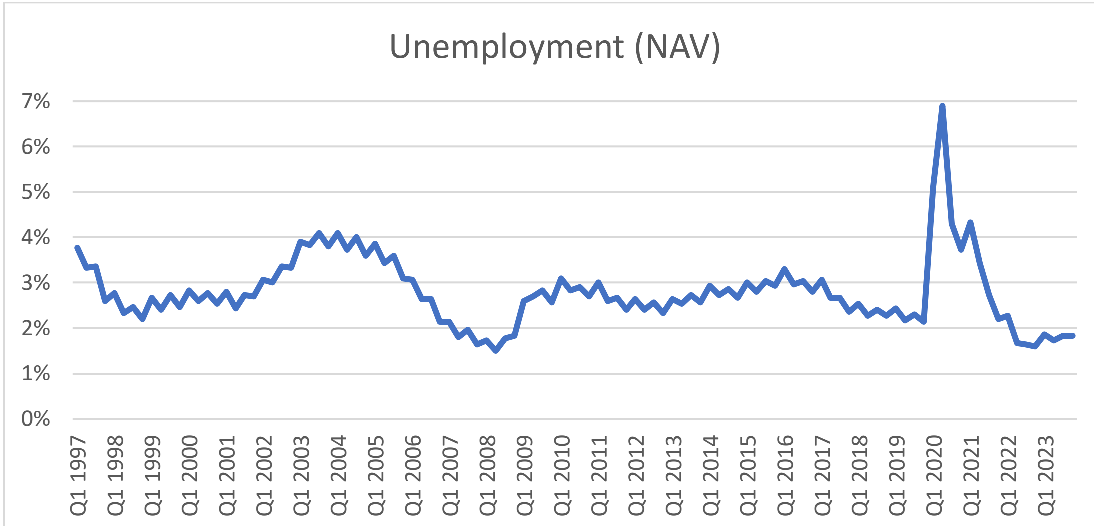
One limitation of both unemployment statistics is that they do not consider individuals deemed unfit to work. According to SSB, 10.7% of the population between 18-67 years receive disability benefits, indicating that 1 in 10 people are not participating in the labor market. Consequently, the actual unemployment rate in Norway is significantly higher than reported in the statistics.

Since this statistic is published on a monthly basis, we have to transform it into quarterly figures. This is done by taking the average of the three months each quarter consists of. As with the HPI's and total wage income variables, unemployment is included in logarithmic form in our models. Below is a graphical representation of the

[10] In Norway, employees accrue holiday pay during the previous year, and it is paid out as a lump sum, usually in June, to cover income during their vacation.
[11] Email correspondence with Kristian Gimling, SSB. Gimling is the contact person for table 09175.

registered unemployed individuals in Norway in nominal terms (i.e. not in logarithmic form):

Figure 19: Registered Unemployed Individuals (NAV) - Norway



Source: NAV

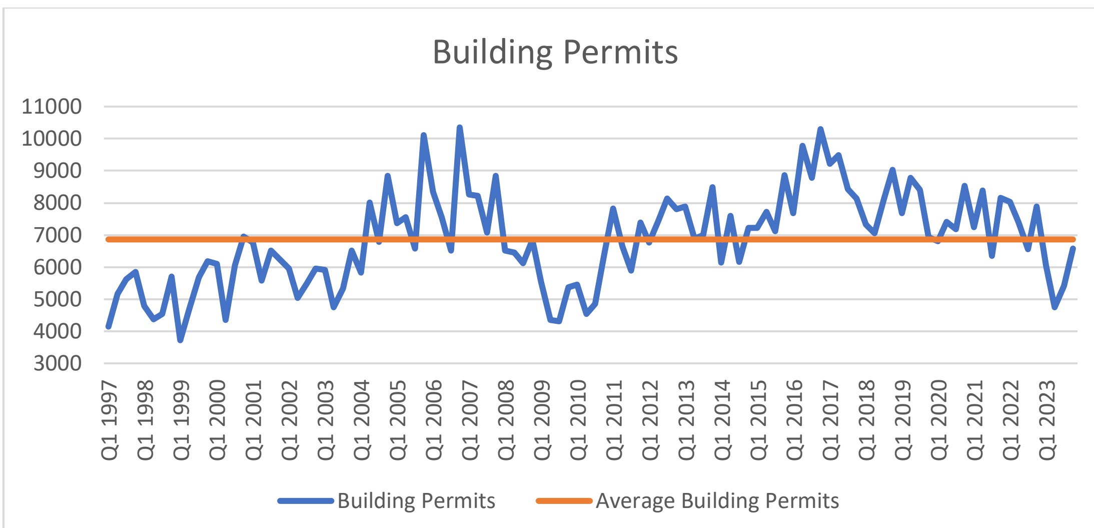
As seen in the graph, the unemployment rate spiked at the start of the COVID-19 pandemic, when national and worldwide lockdowns caused people in certain industries to lose their jobs. As the lockdowns were eased, we observe that the unemployment rate decreased again. To account for and smooth out this extreme effect, we use the 4-quarter rolling average of the unemployment rate in the period Q2 2019 – Q4 2022.

7.5 Building Permits

Building permits are an essential indicator in the housing market, reflecting future housing supply. They represent the authorization for new construction projects, and their numbers can signal the health of the real estate market and broader economy. An increase in building permits typically indicates upcoming growth in housing supply, which can moderate housing prices by balancing demand and supply. Conversely, a decline in permits can suggest a future shortage of housing, potentially driving up prices. Given their significant role in signaling future supply and potential price changes, we have included building permits as one of the variables in our analysis to better understand housing price dynamics. Data for Norwegian building permits are extracted from SSB, Table 03723.

Figure 20 illustrates the quarterly number of building permits from Q1 1997 to Q4 2023. The blue line represents the number of permits issued each quarter, while the orange line shows the average number of permits over the same period. Observing the fluctuations, it's clear that there are periods of increased activity, particularly during economic upturns, and declines during downturns, such as the significant drop observed around 2022, likely due to the COVID-19 pandemic's impact on the construction industry. Just as with the variables HPI's, total wage income, and unemployment, the building permits are expressed in logarithmic form in the models in our analysis. Below is a graphical representation of the building permits in nominal terms (i.e. not in logarithmic form):

Figure 20: Quarterly Building Permits compared to Average Building Permits



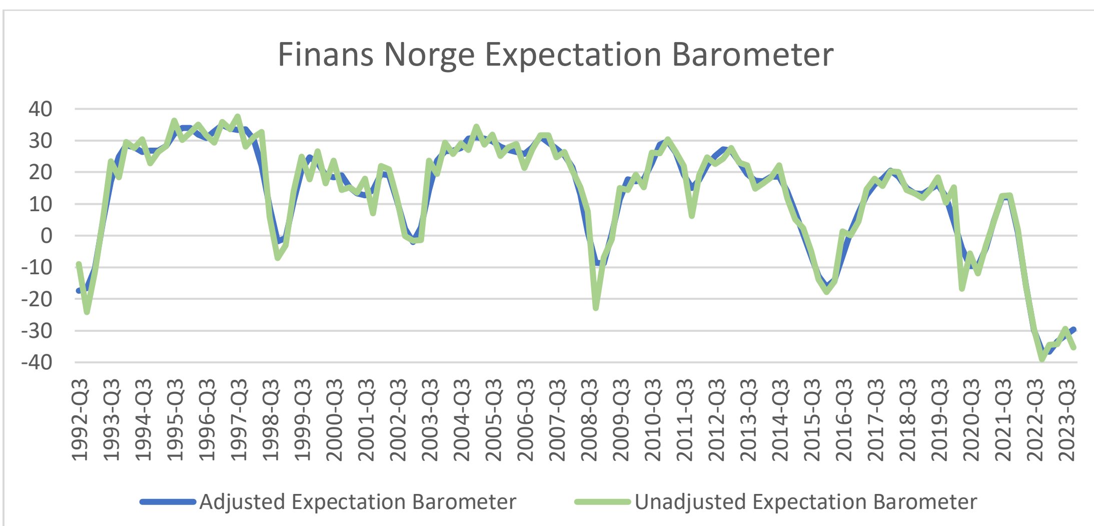
Source: SSB

7.6. Expectation Barometer

Finans Norge's expectation barometer measures household expectations regarding personal and national economic conditions. Jacobsen & Naug (2004) found a strong correlation between this barometer and housing price growth, interest rates, and unemployment rates, leading them to include this indicator in their model to capture expectation effects. Since 1992, Verian Group has conducted quarterly surveys, covering 1,000 respondents each time. The indicator is calculated by subtracting negative responses from positive ones and averaging the results. A positive indicator value reflects a majority of households with optimistic economic outlooks, whereas a negative indicator reflects a majority with pessimistic view. The same five questions have been asked every quarter since the indicator was first introduced (Finans Norge, 2024):

1. *Would you say that your household's economic situation is better, worse, or the same compared to a year ago?*
2. *Do you believe your household's economic situation will be better, worse, or the same a year from now?*
3. *Considering the economic situation of the entire country, do you think the national economy is better, worse, or the same compared to a year ago?*
4. *Do you expect the national economic situation to be better, worse, or the same a year from now?*
5. *Do you think it is a good or bad time for people in general to buy major household items now?*

Figure 21: Finans Norge – Adjusted- and Unadjusted Expectation Barometer



Source: Finans Norge[12] and Verian Group

[12] Statistics on the Expectation Barometer were obtained from Ann Håkonsen, Head of Communications at Finans Norge (Håkonsen, personal communication, May 10, 2024).

7.6.1 Expectation Indicator

Jacobsen & Naug found that Finans Norge's expectation barometer is highly correlated with the growth in housing prices. This aligns with the findings of Poterba (1984), who emphasizes the critical role of future expectations in housing price models. Poterba argues that anticipations about future economic conditions, such as income growth, inflation, and interest rates, significantly influence housing market dynamics. These expectations affect both the supply and demand sides of the housing market, shaping overall price trends. However, as the expectation barometer from Finans Norge measures the economic outlooks for households, it is natural to think that interest rates and unemployment impact households and their outlooks to a great extent. If interest rates are high, most Norwegians will get higher interest payments on their mortgages, which could result in less disposable income. Unemployment could also lead to less disposable income. Hence, it is natural to think that these two variables have a significant impact on the expectation barometer. To solve for this, we estimate an error correction model where we regress the first differenced expectation barometer on the first differenced bank's lending- and unemployment rate, as well as lagged dependent and independent variables to get the following ECM:

(7.1)

$$\begin{aligned} \Delta EXP\_BAR_t = \alpha + \delta_1 \Delta(LEND\_RATE - T)_t + \delta_2 \Delta unemployment_t \\ - \delta_3 EXP\_BAR_{t-1} + \delta_4 (LEND\_RATE - T)_{t-1} \\ + \delta_5 unemployment_{t-1} + \delta_6 SEASON\_SPRING \\ + \delta_7 SEASON\_SUMMER + \delta_8 SEASON\_SPRING + \delta_9 COVID + u_t \end{aligned}$$

Where t represents the time period per quarter, Δ denotes the first difference, and u_t is the error term. Variables denoted in small letters are measured on a logarithmic scale.

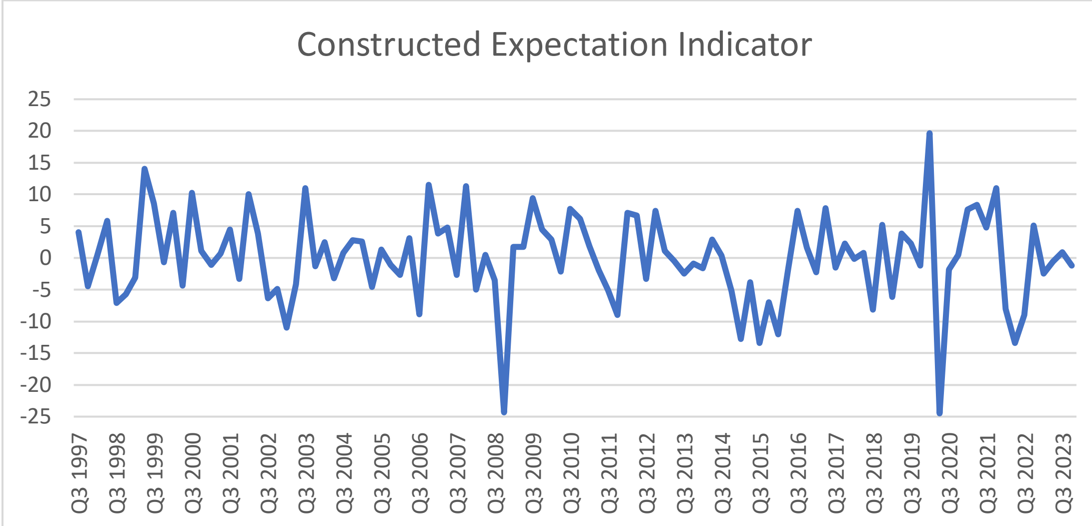
Since the expectation barometer is unadjusted, we also have to account for seasonal effects. We therefore include three dummy variables, $Season\_Spring$, $Season\_Summer$ and $Season\_Fall$. Consequently, the winter season serves as the reference point, meaning that we compare the other seasons against the winter season.

By doing this, we account for seasonal variation in the model. Investigating Figure 21, we observe a significant drop from 15.2 to -16.7 in Q1 2020 to Q2 2020, the largest one-quarter drop in the entire time-series of the expectation barometer. This was likely due to the COVID-19 pandemic, which caused almost immediate global shutdowns and widespread fear. To account for this unprecedented event, we include a dummy variable, COVID, in the ECM model. This dummy variable equals 1 for the period from Q1 2020 to Q4 2022, and 0 otherwise.

After this, we store the residuals from the regression in a new "cleaned" variable: $EXP\_INDICATOR$. The residuals, consequently, explain the variation in the expectation barometer that is not accounted for by the bank's lending rate and the unemployment rate. By doing this, we also avoid the multicollinearity problem, where two or more independent variables are highly correlated, which can distort the regression results. Presence of multicollinearity also violates assumption 3 in OLS, which could significantly reduce the precision of the estimates by inflating their standard errors. This makes the coefficient estimates unstable and sensitive to minor changes in the data, potentially leading to large standard errors and less reliable hypothesis testing. This was discussed in Section 6.1.1.

This approach allows us to isolate the impact of household expectations on the housing market without the confounding influence of these correlated variables. Below is a graphical illustration of the residuals from the ECM, which we've stored in the constructed variable $EXP\_INDICATOR$. We explain how we incorporate this variable into our analysis in Section 8.2.

Figure 22: Residuals from Constructed Expectation Indicator



Source: Finans Norge, Verian Group, and own calculations

The reason for including the constructed expectation variable in the final housing price model is to capture the gap between the actual and predicted values of the expectation indicator. This gap reflects changes in households' expectations driven by other factors than lending rates and unemployment, such as unexpected negative events like wars, stock market crashes, natural disasters, or geopolitical tensions. It can also be influenced by significant policy changes, shifts in global economic conditions, or as we recently experienced, a global pandemic, which we observe from Figure 21 had a major impact on households' expectations.

8.0 Results and Analysis

In this chapter, we will present and analyze the findings from our econometric analysis into the determinants of housing prices in Norway and its four largest cities: Oslo, Bergen, Trondheim, and Stavanger. By employing an error correction model and conducting various statistical tests, we aim to examine the short-term and long-term impacts of key economic variables such as total wage income, bank lending rates, unemployment rates, building permits, and household expectations. This comprehensive analysis will help us understand the dynamics driving housing prices and assess the significance of different factors influencing the real estate market across these regions.

8.1 Stationarity results

As mentioned in Section 6.2, it is essential that the data is sufficiently stationary to accurately represent the relationship between the dependent and independent variables across all time periods. In order to test for stationarity, we employ the Augmented Dickey-Fuller test. We use a combination of the Schwarz Bayesian Information Criteria and looking at how many lags are significant based on the student t-statistic. This was explained in Section 6.3.1. This approach is chosen to avoid a too low test-statistic, so that the variables pass the stationarity test even though they aren't inherently stationary. The variables denoted in small letters are measured on a logarithmic scale. Table 4 shows the ADF results of the included variables:

Table 4: Results from the Augmented Dickey-Fuller tests:

	Test-statistic from ADF		
Variable	**# of Lags**	**With trend With constant**	**No trend With constant**
$norway\_hpi$	5	-2.737	-2.172
$oslo\_hpi$	5	$-3.233*$	-1.955
$bergen\_hpi$	5	-1.969	$-3.661***$
$trondheim\_hpi$	5	-1.823	$-2.784*$
$stavanger\_hpi$	5	-1.332	-1.366
$income$	4	-1.925	-0.398
$unemployment$	4	$-4.498***$	$-4.038***$
$LEND\_RATE(1-T)$	2	-2.494	-2.184
$building\_permits$	4	-2.381	$-3.068**$
EXP_BAR	3	-2.818	-1.118
$EXP\_INDICATOR$	1	$-7.288***$	$-7.175***$

***/ Significant on 1% level, **/ Significant on 5% level, */ Significant on 10% level

Critical values for ADF test with constant and trend: (1%, 5%, 10%): -3.99, -3.43, -3.13
Critical values for ADF test with constant and no trend: (1%, 5%, 10%): -3.43, -2.86, -2.57

From table 4, we can see that $unemployment$ and the constructed $EXP\_INDICATOR$ are stationary at the 1% significance level when we account for trend and without trend. We also observe that $oslo\_hpi$ is barely stationary at the 10% level with trend. Surprisingly, the dependent variables $bergen\_hpi$ and $trondheim\_hpi$ are both significant at the 1% and 10% level, respectively, when we don't account for trend. $building\_permits$ are significant at the 5% level when we without trend. Given their economic context, we believe that the variables are better analyzed with trend. We therefore focus on the results with trend to ensure robustness and avoid spurious conclusions.

We find that all the other variables, apart from $unemployment$ and $EXP\_INDICATOR$, which are already stationary, become stationary after first differencing (i.e. integrated of first order $I(1)$).

8.2 Expectation Indicator

In Section 7.6.1, we described how we construct the expectation indicator. In order to ensure we have constructed the expectation indicator correctly for the time-period we are analyzing, we first set up the error correction model for the same time period as Jacobsen & Naug did in their 2004 analysis.

Table 5: Constructed Expectation Indicator Comparison

	Jacobsen & Naug (Q3 1992 – Q1 2004)		Re-estimation (Q3 1992 – Q1 2004)	
Variable	**Coefficient**	**t-value**	**Coefficient**	**t-value**
$\Delta(LEND\_RATE(1-T))_t$	$-12{,}96$ ***	(6,68)	$-12{,}44$ ***	(6,47)
$\Delta\text{unemployment}_t$	$-0{,}43$ **	(2,47)	$-0{,}43$ **	(2,64)
EXP_BAR_{t-1}	$-0{,}11$	(1,06)	$-0{,}14$	(1,44)
$(LEND\_RATE(1-T))_{t-1}$	$-0{,}40$	(0,42)	$-0{,}77$	(0,81)
$\text{unemployment}_{t-1}$	$-0{,}03$	(0,82)	$-0{,}02$	(0,43)
$SEASON\_SPRING$	0,21 ***	(4,57)	$-0{,}22$ ***	(5,8)
$SEASON\_SUMMER$	0,10 ***	(4,49)	$-0{,}02$	(0,58)
$SEASON\_FALL$	0,22 ***	(5,61)	$-0{,}12$ ***	(3,62)
$Intercept$	$-0{,}07$	(0,39)	0,1	(0,67)
$\#\ of\ Observations$	46		46	
$R2$	0,80		0,8024	
$Adjusted\ R2$			0,7597	

***/ Significant on 1% level, **/ Significant on 5% level, */ Significant on 10% level

Here, we can see that there are very minor deviations in the coefficient estimates and t-values between Jacobsen & Naug's estimation and our re-estimation. The minor differences may be due to the underlying data we used for the bank's lending rate and unemployment rate. Jacobsen & Naug used the unemployment rate published by Aetat, which is now known as NAV. We found NAV's unemployment statistics dating back to 1991. However, this data was monthly, so we had to compute the average of the three months in each quarter to obtain quarterly values.

We also obtained the data for the bank's lending rates from SSB. According to Jacobsen & Naug (2004), they obtained this data from Norges Bank. We were not able to obtain the series published by Norges Bank. Subsequently, there might be small deviations between SSB and Norges Bank's published bank's lending rate that could also cause the deviations we observe in Table 5. The expectation barometer, which is the dependent variable, is the same that Jacobsen & Naug used in their analysis. Hence, we suspect that the two variables leading to the minor differences in the obtained results are the bank's lending rate and unemployment rate.

Overall, we can still see that the bank's lending rate after tax and the unemployment rate explain roughly 80% of the variation in Finans Norge's expectation barometer, as it did with Jacobsen & Naug's (2004) model. Hence, we can conclude with high certainty that we have successfully re-constructed Jacobsen & Naug's error correction model.

Since we were able to replicate Jacobsen & Naug's original constructed expectation indicator variable, we apply the same steps to obtain the expectation indicator variable for the time period we're analyzing, Q1 1997 – Q4 2023. We obtain the following results:

Table 6: Re-estimation Q1 1997 – Q4 2023

	Jacobsen & Naug Method (Q1 1997 – Q4 2023)		**With COVID Dummy (Q1 1997 – Q4 2023)**	
Variable	**Coefficient**	**t-value**	**Coefficient**	**t-value**
$\Delta(LEND\_RATE(1-T))_t$	-9.14^{***}	(3,88)	$-8{,}04^{***}$	(3,48)
$\Delta\text{unemployment}_t$	$-0{,}43^{***}$	(2,69)	$-0{,}17^{**}$	(2,54)
EXP_BAR_{t-1}	$-0{,}18$	(1,62)	$-0{,}13^{***}$	(2,64)
$(LEND\_RATE(1-T))_{t-1}$	$-0{,}17$	(0,29)	$-0{,}73$	(1,18)
$\text{unemployment}_{t-1}$	0,004	0,13	0,03	0,78
$SEASON\_SPRING$	$-0{,}08^{***}$	(3,35)	$-0{,}9^{***}$	(3,41)
$SEASON\_SUMMER$	$-0{,}02$	(0,79)	$-0{,}02$	(0,88)
$SEASON\_FALL$	$-0{,}12^{***}$	(5,00)	$-0{,}13^{***}$	(5,06)
$Intercept$	0,09	0,67	0,20	1,57
$COVID$			$-0{,}08^{***}$	(2,83)
$\#\ of\ Observations$	106		106	
$R2$	0,367		0,415	
$Adjusted\ R2$	0.314		0,360	

***/ Significant on 1% level, **/ Significant on 5% level, */ Significant on 10% level

We observe a drastically lower R^2 for the time-period Q1 1997 - Q4 2023 compared to the previously predicted period from Q3 1992 – Q1 2004, where the bank's lending rate and unemployment rate explained 80% of the variance in the former time-period, as displayed in Table 5. Now, the same variables only explain 36.7% of the variance. This drop in explanatory power indicates that the relationship between the bank's lending rate, unemployment rate, and the expectation barometer has weakened over time. Several factors could contribute to this shift, including changes in economic conditions, policy changes, or evolving consumer behavior. It's also possible that other variables not included in the model have become more significant in influencing household expectations during the later period.

Despite the lower R^2 value, we still find that the key variables remain statistically significant, albeit with different coefficients. For instance, the impact of the lending rate after tax $\Delta(LEND\_RATE(1-T))_t$ is still significant at the 1% significance level, though its coefficient has decreased. Similarly, the unemployment rate $\Delta unemployment_t$ remains significant, but its coefficient is also lower. The seasonal dummy variables continue to show that expectations vary with seasons, consistent with previous findings.

The inclusion of the $COVID$ dummy variable, which captures the effects of the pandemic, also improves the explanatory power of the model. The dummy variable is highly significant, reflecting the substantial impact of the pandemic on household expectations. This finding underscores the importance of accounting for such extraordinary events in economic models. We also tested the ECM with a $FINANCIAL\_CRISIS$ dummy variable, but this was neither significant nor did it increase the R^2 of the model. We therefore excluded this dummy from the constructed expectation indicator.

8.3 Error Correction Model for Housing Prices

The housing price model is an error correction model for the logarithm of the housing prices for Norway, Oslo, Bergen, Trondheim, and Stavanger. The fundamental explanatory variables we include are total wage income in the economy, the average after-tax lending rate of banks, unemployment, building permits, and Finans Norge's expectation barometer adjusted for the effects of bank's lending rates and unemployment. All the variables included were discussed in detail in Chapter 7. The constructed housing price model allows us to look at short-term and long-term effects, where the long-term effects are listed in brackets in equation 8.1 below:

(8.1)

$$
\begin{aligned}
\Delta housingprice_t &= \alpha + b_1 \Delta income_t + b_2 \Delta\big(LEND\_RATE(1-T)\big)_t \\
&+ b_3 EXP\_INDICATOR_t \\
&- \lambda[housingprice_{t-1} - d_1(LEND\_RATE(1-T))_{t-1} \\
&- d_2 unemployment_t - d_3 building\_permits_{t-1}] + \beta_1 COVID \\
&+ \beta_2 FINANCIAL\_CRISIS + \beta_3 SEASON\_SPRING \\
&+ \beta_4 SEASON\_SUMMER + \beta_5 SEASON\_FALL + u_t
\end{aligned}
$$

Where variables denoted in small letters are measured on a logarithmic scale.
As we discussed Section 6.6, the coefficients b_i are short-term parameters, λ is the error correction parameter, and d_i are the long-term parameters. The long-term parameters are included in the bracket in the equation. As mentioned, the error correction parameter $\lambda = -c$. Hence, c has to take on a value between between 0 and -1 in order for us to conclude that the model has a long-term equilibrium relationship.

We also incorporate five dummy variables in our model: $SEASON\_SPRING$, $SEASON\_\ SUMMER$, and $SEASON\_FALL$ are seasonal dummy variables. These dummies are included in the housing price model (equation 8.1), and the constructed expectation indicator (equation 7.1). This is because many of the variables included in these models are significantly impacted by seasonal trends, and hence, need to be accounted for. We also choose to incorporate two additional dummies to account for extreme events: $COVID$ and $FINANCIAL\_CRISIS$. The $COVID$ dummy variable is included to account for the significant impact of the COVID-19 pandemic on the housing market. This variable takes on a value of 1 from Q1 2020 to Q4 2022 and 0 otherwise. The $FINANCIAL\_CRISIS$ dummy variable captures the effects of the global financial crisis, taking on a value of 1 from Q2 2007 to Q4 2009, and 0 otherwise. These dummies allow the model to adjust for these extraordinary events and avoid attributing their effect to the fundamental explanatory variables.

8.3.1 Estimation of Error Correction Model

We estimate the following error correction models for Norway, Oslo, Bergen, Trondheim, and Stavanger:

Table 7: ECM for Norway and Oslo

	Q1 1997 – Q4 2023	
Variable	**Norway Coefficient (Standard Error)**	**Oslo Coefficient (Standard Error)**
$\Delta income_t$	$-0{,}010$ (0,388)	$-0{,}116$ (0,059)
$\Delta(LEND\_RATE(1-T))_t$	$-2{,}926$ *** (0,502)	$-1{,}713$ ** (0,769)
EXP_INDICATOR_t	0,041 *** (0,015)	0,025 (0,023)
$housingprice_{t-1}$	$-0{,}039$ *** (0,005)	$-0{,}031$ *** (0,008)
$(LEND\_RATE(1-T))_{t-1}$	$-1{,}130$ *** (0,201)	$-1{,}058$ *** (0,298)
unemployment_t	$-0{,}032$ *** (0,009)	$-0{,}016$ (0,013)
$building\_permits_{t-1}$	$-0{,}004$ (0,009)	$-0{,}011$ (0,014)
$COVID$	0,010 * (0,005)	0,004 (0,008)
$FINANCIAL\_CRISIS$	$-0{,}018$ *** (0,005)	$-0{,}023$ *** (0,008)
$SEASON\_SPRING$	$-0{,}018$ *** (0,004)	$-0{,}021$ *** (0,007)
$SEASON\_SUMMER$	$-0{,}034$ *** (0,004)	$-0{,}028$ *** (0,007)
$SEASON\_FALL$	$-0{,}044$ *** (0,004)	$-0{,}039$ *** (0,007)
$Intercept$	0,234 *** (0,083)	0,295 ** (0,127)
$\#\ of\ Observations$	106	106
$R2$	0,725	0,458
$Adjusted\ R2$	0,688	0,387

***/ Significant on 1% level, **/ Significant on 5% level, */ Significant on 10% level

Table 8: ECM for Bergen, Trondheim, and Stavanger

	Q1 1997 – Q4 2023		
Variable	**Bergen Coefficient (Standard Error)**	**Trondheim Coefficient (Standard Error)**	**Stavanger Coefficient (Standard Error)**
$\Delta income_t$	0,022 (0,045)	−0,001 (0,038)	0,030 (0,049)
$\Delta(LEND\_RATE(1-T))_t$	−3,759 *** (0,588)	−3,575 *** (0,494)	−3,092 *** (0,642)
$\mathrm{EXP\_INDICATOR_t}$	0,052 *** (0,018)	0,053 *** (0,015)	0,073 *** (0,019)
$housingprice_{t-1}$	−0,039 *** (0,007)	−0,035 *** (0,005)	−0,047 *** (0,007)
$(LEND\_RATE(1-T))_{t-1}$	−1,210 *** (0,252)	−1,014 *** (0,207)	−1,544 *** (0,263)
$\mathrm{unemployment_t}$	−0,025 ** (0,010)	−0,023 *** (0,008)	−0,047 *** (0,011)
$building\_permits_{t-1}$	−0,012 (0,010)	−0,007 (0,009)	−0,024 ** (0,011)
$COVID$	0,005 (0,006)	0,008 (0,005)	0,005 (0,006)
$FINANCIAL\_CRISIS$	−0,023 *** (0,006)	−0,021 *** (0,005)	−0,007 (0,006)
$SEASON\_SPRING$	−0,026 *** (0,005)	−0,018 *** (0,004)	−0,019 *** (0,005)
$SEASON\_SUMMER$	−0,038 *** (0,005)	−0,034 *** (0,004)	−0,027 *** (0,006)
$SEASON\_FALL$	−0,049 *** (0,005)	−0,045 *** (0,004)	−0,047 *** (0,005)
$Intercept$	0,331 *** (0,098)	0,255 *** (0,081)	0,401 *** (0,108)
$\#\ of\ Observations$	106	106	106
$R2$	0,723	0,766	0,635
$Adjusted\ R2$	0,686	0,735	0,587

***/ Significant on 1% level, **/ Significant on 5% level, */ Significant on 10% level

The following tables show the results from the regressions. Table 7 shows the results for Norway and Oslo, and Table 8 shows the results for Bergen, Trondheim, and Stavanger. The short term-parameters are listed first, followed by the error correction parameter, the long-term parameters, dummy variables, and lastly the R^2.

8.4 Testing for Cointegration

In one-step error correction models, we can look at the significance level of the error correction parameter (λ) to see whether the variables included in the model are cointegrated or not. All five error correction parameter coefficients yield a result between 0 and -1, indicating a long-term equilibrium relationship, as discussed in Section 8.3. All the error correction parameter coefficients are also statistically significant on the 1% significance level.

To further confirm that the variables are cointegrated, we perform an ADF test on the residuals from the five models. If the residuals are stationary, this further confirms that the variables are cointegrated. We use SBIC to determine that the optimal number of lags to include are one. We get test statistics of -7,376, -6,427, -7,705, -6,365, and -4,780 for Norway, Oslo, Bergen, Trondheim, and Stavanger. These are all significant on the 1% level. We can thereby confirm that there is a long-term equilibrium relationship between the variables in the model, and the model provides consistent estimates.

8.5 Testing for Autocorrelation

We can use statistical tests to test for autocorrelation. In their 2004 analysis, Jacobsen & Naug used the Durbin-Watson test to test for autocorrelation in the residuals. However, as Fredriksen (2007) pointed out, the DW test is not suitable when the model contains lagged variables. This was also discussed in Section 6.4.1. We therefore apply the Ljung-Box test. The Ljung-Box test is performed with 8 lags, as we're working with quarterly data, and we want to include the effect of each season two times. We get that none of the variables are significant, indicating that the residuals are not autocorrelated. If these would've been significant, we would've had to reject the null hypothesis that there is no autocorrelation in the residuals. Hence, for Norway, Oslo, Bergen, Trondheim, and Stavanger, we fail to reject the null hypothesis that there is no autocorrelation in the residuals, indicating that there is no evidence of autocorrelation in the residuals. As explained in Section 6.4, autocorrelation is a common issue in time-series regression. While it violates OLS assumption 5 Homoskedasticity, i.e. that residuals in different time periods should be independent, the OLS estimates will remain unbiased. However, they will no longer be BLUE (Best Linear Unbiased Estimator).

8.6 Interpretation of the Coefficients from the Analysis

In this section we will interpret the coefficients from the results from our five housing price models. Understanding these coefficients is crucial as they provide insights into how different economic factors influence housing prices across Norway and its major cities. We will examine both the short-term and long-term effects of the variables in Tables 7 and 8. Additionally, we will assess the impact of seasonal variations and significant economic events, as captured by dummy variables.

8.6.1 Error Correction Parameter

As we described to detail in Section 6.6, the error correction parameter measures the long-term effect a one unit increase in x has on y. Since the coefficient of the lagged variable $housingprices_{t-1}$ is between 0 and -1, there exists a long-term equilibrium relationship. The larger the value, the quicker the adjustment back to equilibrium, and vice versa. We obtain fairly small values for the error correction parameter for all five models, with coefficients of $-0{,}039, -0{,}031$, $0{,}039$, and $-0{,}035, -0{,}047$.
It is possible to calculate the halving time, i.e. the time it takes for half of any deviation to be adjusted back to equilibrium. We use the following formula to find the halving time for Norway as a whole and the four cities (Norges Bank, 2024):

$$(1-\lambda)^t = 0{,}5$$

Rearranging this formula to solve for t, we get:

$$t = \frac{\ln(0{,}5)}{\ln(1-\lambda)}$$

Where λ error correction parameter for the five models.

Applying this formula to our models, we observe very slow halving times, indicating a slow-moving adjustment process back to equilibrium. Specifically, Oslo has the slowest adjustment speed with a halving time of 22 quarters, or approximately 5.5

years. The halving times for the other models are as follows: Norway at 18 quarters (4.5 years), Bergen at 18 quarters (4.5 years), Trondheim at 20 quarters (5 years), and Stavanger at 15 quarters (3.75 years).

These extended halving times highlight that deviations from the long-term equilibrium in housing prices take a considerable amount of time to correct. Such slow adjustments suggest that long-term shocks or changes in the housing market can have prolonged effects before the system returns to its equilibrium state. The slow halving times observed in our models could also potentially be attributed to the time-period we're examining in our analysis. After the great financial crisis in 2008, Norway experienced a prolonged period of low-interest rates until the start of 2023, this 15-year period of low interest rates could potentially have delayed the market's return to equilibrium following any deviations, as the cost-of-borrowing were at historical low levels, meaning that the bank's lending rate may not have impacted the housing prices to such a big extent as they did in Jacobsen & Naug's initial 2004 analysis.

8.6.2 Bank's Lending Rate

The bank's lending rate is included both as a short-term parameter and long-term parameter. We observe that the both the short-term and long-term bank's lending rate is statistically significant at the 1% significance level for all five models, except from Oslo, where the short-term parameter is statistically significant at the 5% level.

The net effect of a 1% increase in the bank's lending rate, after accounting for the marginal tax rate on capital income and expenses (as of Q4 2023), is effectively 0.78% $(1 - 0.22)$. According to our models, this 1% increase in the bank's lending rate would result in a decrease in Norwegian housing prices by approximately 2.28% after the first quarter (calculated as $2.926 * 0.78$). The impact varies slightly across different cities, with housing prices in Bergen, Trondheim, and Stavanger expected to drop by 2.93%, 2.79%, and 2.41%, respectively. These figures are hypothetical, as the Norwegian central bank will not increase the key policy rate by 100 basis points in one quarter unless there is an extreme situation in the economy.

Interestingly, the bank's lending rate has a comparatively smaller effect on Oslo's housing market, where the expected drop is only 1.33% after the first quarter. This finding aligns with economic observations, as Oslo's housing market has outperformed those of other cities, with housing prices increasing by more than an additional 140% compared to the other cities since 1997. This significant growth likely reflects the unique economic and demographic factors driving housing demand in the Norwegian capital, making it less sensitive to changes in interest rates.

In the long run, a decrease in the bank's lending rate will have a similar impact on all the cities, where a 1% increase in lending will only results in a drop in housing prices in the range of 0.81% to 1.2%. The deviation from the estimated long-term equilibrium will adjust by 3-4.5% for each of the cities per quarter. The observed results indicate that interest rates exert a stronger influence on housing prices in the short term compared to the long term across Norway and its major cities. This phenomenon, known as "overshooting" (Jacobsen and Naug, 2004), means that the immediate impact of an interest rate change is more pronounced than its long-term effect. This doesn't necessarily indicate a housing bubble but rather suggests that a temporary spike (decrease) in housing prices occurs following an interest rate reduction (increase), surpassing the long-term adjustment in fundamental value.

8.6.3 Unemployment

The registered unemployment rate from NAV, as discussed in Section 7.4, is part of the long-term equilibrium relationship we estimate with the error correction models. Unlike the other variables we've included in the long-run parameters, it is not lagged. Normally, all the variables in the error correction terms are lagged.

We find that the unemployment rate is statistically significant for Norway, Bergen, Trondheim, and Stavanger. In Oslo, it is not statistically significant, even at the 10% level. In Trondheim and Stavanger, the unemployment rate is statistically significant at the 1% significance level, while in Norway as a whole and Bergen, the unemployment rate is statistically significant at the 5% level.

To understand the impact of changes in the unemployment rate on housing prices, we analyzed the effects of a 1 percentage point increase from 4% to 5% in unemployment, which translates to a 25% relative increase in the unemployment rate. Accordingly, this would cause the housing prices in Norway in the long-term to decrease by approximately 0.8% (calculated as $-0.032 * 25$). We observe the highest drop in Stavanger, with a decrease in housing prices of 1.2%. In Trondheim, the decrease would be 0.58%, in Bergen, 0.63%, and in Oslo, 0.4%, although the result for Oslo is not statistically significant.

These results highlight the varying sensitivities of housing prices to changes in the unemployment rate across different regions in Norway. While Trondheim and Stavanger show a significant response to changes in unemployment, Oslo's housing market appears less affected, with the lack of statistical significance suggesting that other factors may play a more substantial role in this city. When examining the housing price index for Stavanger in Section 7.1 and the price vs. rent graph in Section 4.3.1, we observe that housing prices in Stavanger have been significantly impacted. The fact that a potential increase in the unemployment rate hits Stavanger the hardest is noteworthy, as jobs in the oil industry are cyclical to a fair amount. This means that downturns in the oil industry, which can lead to higher unemployment, can in turn negatively impacts housing prices in Stavanger.

Our results align with economic intuition that higher unemployment leads to lower housing demand, as fewer people can afford to buy homes if they don’t have a stable income as a result of being unemployed.

8.6.4 Wages and Income

In Section 4.5 and 4.6, we discussed the Norwegian "Boliglånsforskriften," which stipulates that the maximum mortgage amount is capped at five times your income. Consequently, we anticipated that income would significantly impact housing prices in our models. This expectation is grounded in the assumption that higher income levels would naturally allow individuals to take on more debt, thereby increasing demand for housing.

However, our results indicate that income does not have a statistically significant effect on housing prices in any of our models. As can be seen in Figure 5 and 6, all coefficients for the income variable are close to zero, with Stavanger's coefficient at 0.030 and Oslo's at -0.116. This implies that total wage income in the economy explains little to none of the variation in housing prices according to our model. This finding is contrary to economic theory, which posits that an increase in income should, ceteris paribus[13], lead to higher housing prices.

Interestingly, from Q1 1997 to Q4 2023, the total wage income in the economy increased by 314% (SSB, 2024), while housing prices in Norway surged by 470% during the same period (Finn.no, Eiendomsverdi, EFF, NEF and Eiendom Norge, 2024). This discrepancy suggests that other factors than income may have played a more significant role in driving up housing prices. Despite the significant rise in wage income, its negligible effect on housing prices in our models highlights the complexity of the housing market and the multifaceted factors that drive housing prices.

8.6.5 Building Permits

From economic theory, we expect that a larger supply should impact housing prices negatively through increased supply of housing. This is confirmed by our five models, where all the coefficients for the variable $building\_permits_{t-1}$ are negative. However, the only coefficient that is statistically significant is the coefficient for Stavanger, where we observe a coefficient of $-0{,}024$, with a 5% significance level.

We only include this variable in the long-run parameters, as it's natural to believe that it will take time from the issuance of building permits to the actual completion and availability of new housing units. This lag effect reflects the time required for construction and development processes, suggesting that changes in building permits

[13] Ceteritus paribus = All other things being equal

today will influence housing prices over a more extended period rather than immediately.

An interesting observation is that 2023 has been a year of historical low building permits. We have to go back to Q3 2011 to see fewer building permits issued that that of Q2- and Q3 2023 (SSB, 2024). This might be due to Norges Bank aggressive interest rate hikes we've experienced in the last 2-3 years. In fact, since Q3 2021, the key policy rate has increased from 0% to 4.25%, as of Q4 2023 (Norges Bank, 2024). This means that financing has gotten a lot more expensive lately, which impacts the profitability of taking on projects. Hence, this may be one of the reasons we now observe the lowest numbers of building permits we've had in over 13 years. Although we only find $building\_permits_{t-1}$ statistically significant in Stavanger, and not in the other models, we still believe building permits should be included in the model, as economic theory is quite evident on the fact that housing construction affects housing prices.

8.6.6 Expectation Indicator

When estimating the effects of the constructed expectation indicator, it's important to remember that this reflects the variation in the expectation barometer that is not accounted for by the bank's lending rate and unemployment rate. This was discussed in detail in Section 7.6 and 7.6.1. We include this variable as a short-term parameter in our model because people's perception of the economic outlook today may differ significantly from their perceptions in the next quarter, or year. Hence, we are particularly interested in examining the short-term effects.

From our analysis, we can see that the $EXP\_INDICATOR\_t$ is statistically significant at the 1% level in all the models besides Oslo, where it lacks statistical significance according to our analysis. We observe that all the coefficient estimates are positive, indicating that a positive outlook leads to an increase in housing prices, which aligns with economic intuition. Although the coefficients are statistically significant, they are relatively small, indicating that while household expectations do have an impact on housing prices, this impact is not overwhelmingly large.

In Oslo, the lack of statistical significance suggests that other factors may overshadow the effect of household expectations on housing prices. This could be due to the unique economic and demographic dynamics in the capital, which may include stronger influences from factors such as population growth, income levels, and broader economic opportunities.

8.6.7 Dummy Variables

As mentioned in Section 8.3, we introduce five dummy variables to account for seasonal effects and extreme events. The seasonal dummies $SEASON\_SPRING$, $SEASON\_SUMMER, SEASON\_FALL$ are all statistically significant at the 1% level across all five models. Each of these seasonal dummies has a negative coefficient, which aligns with historical data indicating that most year-over-year increases in housing prices typically occur in the first half of the year, with the first quarter showing the strongest growth (Eiendom Norge, 2024). This pattern has been consistent over several years, with the first quarter usually displaying a significant rise in housing prices compared to other quarters. Our models use the winter season (Q1) as the base, so these results are consistent with economic intuition.

We also observe that the coefficients for the $FINANCIAL\_CRISIS$ variable are all negative. This is in accordance with the graphical illustrations of our HPI's, which show a drop in housing prices during this period. All coefficients are statistically significant at the 1% level, except for Stavanger, where the coefficient does not show any statistical significance. We also observe that Oslo and Bergen were the most impacted cities during the financial crisis, while Stavanger was the least impacted, according to the coefficient estimates. This observation is consistent with the lack of statistical significance for the dummy variable in Stavanger.

Lastly, the $COVID$ dummy variable is not statistically significant in any of the individual cities we investigated. However, it is significant for Norway as a whole at the 10% level. All the coefficients for this variable are positive, which makes sense given that the key policy rate was lowered to 0% during the second quarter of 2020

(Norges Bank, 2024), making borrowing costs cheaper and likely supporting housing prices.

8.7 Discussion of the Model

Our model aims to provide a comprehensive analysis of the factors influencing housing prices in Norway, incorporating various economic indicators and employing robust econometric techniques. By leveraging the OLS method, ECMs, and tests for stationarity and cointegration, we strive to ensure the reliability and validity of our findings. The inclusion of both macroeconomic variables and the expectation indicator offers a holistic view of the housing market dynamics, allowing for both short-term and long-term analysis.

In their initial analysis, Jacobsen & Naug estimated the fundamental drivers of housing prices using a similar model to the one we've estimated above. Although their analysis shows statistically significant results backed by economic tuition, their estimation period was only from Q2 1990 – Q1 2004, meaning they only had 56 observations. We expanded this to cover the time-period from Q1 1997 – Q4 2023, meaning that our sample size is double what theirs were. We believe our time-period is more sufficient for estimating the long-term equilibrium relationship between the variables in our model, as the longer the time-period, the more consistent the estimates.

Since we are investigating housing prices in Norway as a whole, along with its four largest cities - Oslo, Bergen, Trondheim, and Stavanger - it's clear that including city-specific variables would vary across these cities. For example, the unemployment rate will differ in each city. However, using city-specific unemployment rates would necessitate a significant reduction in our estimation period due to limited data availability. Additionally, much of the data for smaller geographical areas is measured annually, requiring transformation into quarterly intervals, which could introduce inaccuracies and inconsistencies. Therefore, we opted for a more consistent approach by using national-level variables where city-specific data was unavailable. This decision allows us to maintain a longer time series for analysis, ensuring robustness and reliability in our estimates while acknowledging the limitations imposed by using national data rather than city-specific data. One advantage of using the same explanatory variables for all five models, however, is that it allows us to evaluate the housing prices based of off the same variables, making it easier to compare the models against one another.

A potential weakness with the model is the issue of simultaneity. This occurs when an explanatory variable in a regression model is determined simultaneously with the dependent variable, creating a situation where there is a two-way causality. This means the explanatory variable affects the dependent variable, and the dependent variable also affects the explanatory variable. Consider the relationship between building permits and housing prices. Ideally, more building permits can lead to increased future housing supply, potentially moderating housing prices. However, current housing prices also influence the issuance of building permits; high prices incentivize developers to apply for more permits, anticipating higher profits. This creates a feedback loop where increased building permits signal more housing supply, leading to lower prices, while high housing prices encourage more building permits.

Since we are investigating housing prices in Norway as a whole, and its four major cities - Oslo, Bergen, Trondheim, and Stavanger - we have to be aware that the Norwegian HPI is significantly impacted by these cities. Oslo, being the largest housing market in Norway, naturally exerts a greater influence on the Norway HPI than the Stavanger HPI for example. As a result, trends and fluctuations in Oslo's housing market are likely to have a more pronounced effect on the overall Norway HPI compared to the other cities. We still chose to include the housing prices in Norway as a whole to give a more holistic view on the Norwegian housing market. This approach allows us to compare deviations in the cities we're investigating against the national average. However, it's important to recognize that the four cities significantly impact the Norway HPI, and as a result, the trends observed in this HPI may closely mirror those in the four cities we're observing in our analysis.

A strength of our analysis is that the observation period includes an economic shock two economic shocks, which are the financial crisis and the COVID-19 pandemic, and the model seems to handle these economic shocks well. The R^2(explanatory power) of the five models is also high, with R^2 values between 63% and 77% for Norway, Bergen, Trondheim, and Stavanger, while it is significantly lower in Oslo, at around 45%. This suggests that housing prices in Norway, Bergen, Trondheim, and Stavanger are better explained by the fundamental explanatory variables included in our analysis than those in Oslo. In the article *House price determinants: fundamentals and underlying factors* (2013), Algieri argues that low explanatory power in econometric housing price models explained by fundamental factors can be seen as a possible indication of a housing bubble. Based on this, there could be a greater risk of there being a housing bubble in Oslo than in the remaining cities and the country as a whole. This makes sense, as 55% of the variation of our model for Oslo is not explained by the model, suggesting that housing prices in Oslo are explained by other than those included in the model.

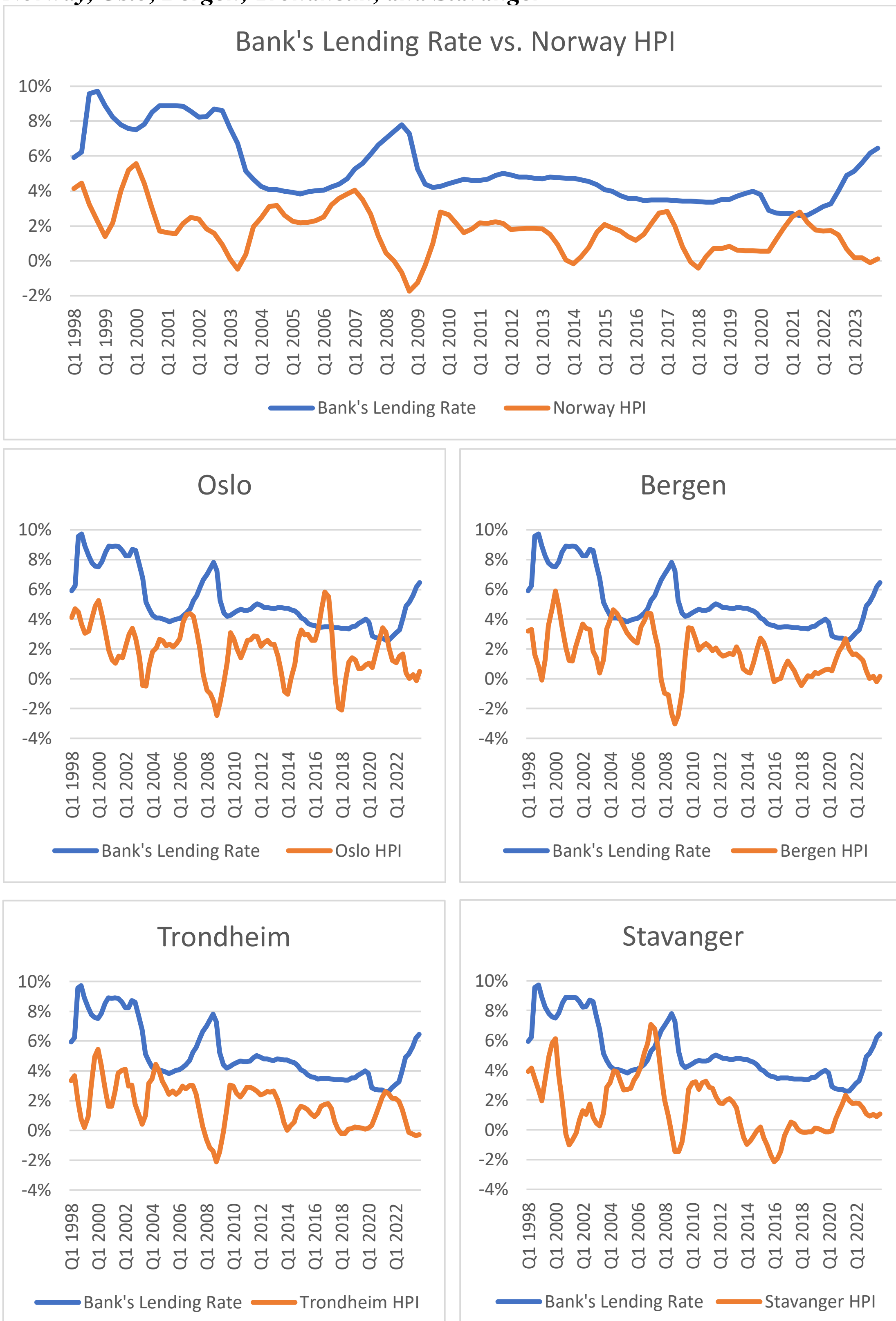
A strength of our analysis is that the observation period includes two economic shocks, the financial crisis and the COVID-19 pandemic, and the model seems to handle these economic shocks well. The R^2(explanatory power) of the five models are also high, with R^2 values between 63% and 77% for Norway, Bergen, Trondheim, and Stavanger, while it is significantly lower in Oslo, at around 45%. This suggests that housing prices in Norway, Bergen, Trondheim, and Stavanger are better explained by the fundamental explanatory variables included in our analysis than in Oslo. In the article "*House price determinants: fundamentals and underlying factors*" (2013), Algieri argues that low explanatory power in econometric housing price models explained by fundamental factors can be seen as a possible indication of a housing bubble. Based on this, there could be a greater risk of a housing bubble in Oslo than in the remaining cities and the Norwegian housing market as a whole. This makes sense, as approximately 55% of the variation in our model for Oslo is not explained by the included variables, suggesting that housing prices in Oslo are influenced by factors not captured by the model.

Our results are also fairly similar to those of Jacobsen & Naug, although the explanatory power of our models is lower than in their analysis. Like them, we find that the bank's lending rate and unemployment are the two most important explanatory variables for housing prices. Of these two, the bank's lending rate has the most significant impact on housing prices. Specifically, a change in the bank's lending rate immediately affects borrowing costs, which in turn influences the affordability and demand for housing. This is reflected in the strong short-term effects we observe across all models, with higher lending rates leading to noticeable decreases in housing prices across all five models.

8.8 Further Discussion of the Impact of the Bank's Lending Rate

As we discussed in Section 8.6, the bank's lending rate was the variable that impacted housing prices the most for Norway and all four cities, both in the short-term and long-term. To further test this, we graphed the bank's lending rate and calculated the 4-quarter rolling average of the quarterly change in housing prices. We used the 4-quarter rolling average to better visualize the trend in housing prices for the five models. Figure Series 4 below show the relationship between the bank's lending rate and the HPI's for Norway, Oslo, Bergen, Trondheim, and Stavanger:

Figure Series 4: Bank's Lending Rate vs. HPI 4-Quarter Rolling Average for Norway, Oslo, Bergen, Trondheim, and Stavanger



Source: SSB, Source: Finn.no, Eiendomsverdi, EFF, NEF, Eiendom Norge, and own calculations

In the graphs in Figure Series 4, we observe a general inverse relationship between the bank's lending rate and the HPI's across all regions. When the lending rate increases, housing prices tend to decrease, reflecting the relationship we discovered in our analysis in Chapter 8. Conversely, when the lending rate decreases, housing prices generally rise.

Nationally, this trend is clearly seen, with significant HPI drops during spikes in the lending rate, especially during the financial crisis and economic downturns. Bergen and Trondheim show pronounced fluctuations, indicating high sensitivity to borrowing cost changes, while Stavanger shows the similar inverse relationships with slightly more moderate effects. Oslo, on the other hand, seems to not be as affected by the lending rate in the years after the financial crisis, as we observe the housing prices fluctuating to a great extent between 2010-2019, without there being significant changes in the lending rate. This could suggest that additional factors affect the housing price dynamics to a greater extent in Oslo than the rest of the cities and Norway as a whole. This can also be reflected in Oslo having the lowest R^2 amongst our five models, indicating that other factors impact the capital's housing prices, as discussed in Section 8.7.

9.0 Conclusion

This thesis has analyzed the housing market for Norway, and its four largest cities: Oslo, Bergen, Trondheim, and Stavanger. The research question was: "Do current housing prices in Norway, and its four major cities - Oslo, Bergen, Trondheim, and Stavanger - reflect fundamental values?".

To address this question, we first examined the Norwegian housing market in Chapter 2, which provided a comprehensive analysis of the Norwegian housing market's long-term stability despite historical crises like the “Kristianiakrakket”, the World Wars, the 1987-1993 banking crisis, and the 2008 financial crisis. The results show that each crisis impacted housing prices differently across regions, with Oslo often being the most severely affected. The Norwegian housing model, designed to maximize home ownership, is also emphasized. As of Q4 2023, 76% of households own their homes, while 82% of private individuals own their homes. This highlights the liberalization and policies aimed at promoting home ownership, which may have been a decisive factor in driving housing prices beyond what fundamental values would suggest.

In Chapter 4, we identified that housing prices in Norway, adjusted for inflation, increased by 340% at their peak in Q2 2022, compared to a 107% increase in the Consumer Price Index over the same period, indicating potential overvaluation. This is further supported by recent declines in real housing prices, which have fallen by 11.42% across Norway from the peak in Q2 2022 to Q4 2023. Specifically, the declines were 10.24% in Oslo, 11.47% in Bergen, 13.05% in Trondheim, and 6.31% in Stavanger over this period. Despite these declines in real terms, nominal housing prices continue to rise, suggesting that prices may still be inflated relative to the overall economic growth.

The price-to-rent ratios in the four cities have also shown significant increases. From Q1 2012 to Q4 2023, the price relative to rents increased by 43 points in Oslo, 19 points in Bergen, 29 points in Trondheim, and 11 points in Stavanger. When we compared this to the commercial real estate office sector, we did not observe the same patterns, as prices and rents co-moved to a much greater extent in this sector. The upward trend in private housing prices relative to rental prices over the last 12 years, particularly in Oslo and Trondheim, could suggest possible market overvaluation.

Furthermore, for the first time since 1990, the cost of owning a property exceeds the rental income, resulting in a negative yield gap in Oslo. From 2021 to 2023, the cost of owning property has increased by 220%, while rental prices only increased by 23% over the same period. Since Q3 2019, the number of secondary homes in Oslo have decreased by 9.5%. We expect this trend to continue as long as leasing remains unprofitable. This could, in turn, cause rental prices to spike, prompting more people to buy homes, potentially further inflating housing prices. This creates a feedback loop where rising housing prices and decreasing rental supply drive more people to purchase homes, pushing prices even higher. In Section 4.4, we suggest that for the market to return to equilibrium, one or more of the following must occur: housing prices falling, interest rates being lowered, and/or rental prices increasing.

Additionally, our analysis of commercial real estate versus residential housing showed that commercial real estate prices have increased at a much slower rate than residential prices across all four cities. From 2008 to 2023, the private housing market in Oslo, Bergen, Trondheim, and Stavanger increased by 141%, 76%, 97%, and 47%, respectively. In contrast, commercial real estate prices "only" rose by 45%, 15%, and 33% in Oslo, Bergen, and Trondheim, while falling by 25% in Stavanger. This disparity suggests that the private housing market may be overvalued compared to the commercial real estate market, which is typically priced based on cash flows. The significant increases in private housing prices indicates that prices may be driven by irrational behavior or other non-fundamental factors, further supporting the possibility of an inflated market.

In our econometric analysis, presented in Chapter 8, we constructed housing price models for Norway, Oslo, Bergen, Trondheim, and Stavanger. The analysis revealed the adjustment speed towards an equilibrium price determined by fundamental factors. The results showed that Oslo is the city with the slowest adjustment back to equilibrium (22 quarters), while Stavanger had the fastest adjustment (15 quarters). The slow adjustment speed in Oslo suggests a prolonged deviation from fundamental values, which could indicate speculative behavior or structural issues within the Norwegian capital's housing market. This slow adjustment is reflected in Oslo's halving time of approximately 22 quarters, or 5.5 years, significantly longer than Stavanger's 15 quarters, or 3.75 years. Such extended periods of deviation can lead to higher volatility and unpredictability in housing prices, making it harder to draw conclusions as to whether the city's housing prices are indeed backed by fundamental factors.

Our analysis also showed that the bank's lending rate and unemployment are the factors with the highest impact on housing prices across all regions, with the bank's lending rate showing significant short-term and long-term impacts. A 1% increase in the lending rate, adjusted for tax, leads to a decrease in housing prices by 2.28% in Norway as a whole. The effect is more pronounced in Bergen, Trondheim, and Stavanger, where housing prices decrease by around 2.93%, 2.79%, and 2.41% respectively. Oslo's housing market, on the other hand, shows a smaller decrease of 1.33%, indicating its unique dynamics and possibly higher resilience to interest rate changes. This aligns with the observed speculative behavior and potential overvaluation in Oslo's market.

Unemployment also significantly impacts housing prices in the long run, particularly in Stavanger and Trondheim, where it is statistically significant at the 1% level. In Stavanger, a 1% increase in the unemployment rate leads to a 1.2% decrease in housing prices, potentially reflecting the region's economic reliance on the oil and gas industry. Trondheim shows a 0.58% decrease. For Norway and Bergen, the impact is statistically significant at the 5% level, with housing prices decreasing by 0.8% and 0.63%, respectively. In contrast, Oslo's housing market does not exhibit a statistically significant relationship with unemployment rates, suggesting that other factors may overshadow the effect of unemployment on housing prices.

When looking at the fit of the models, we observe that the explanatory power of the five housing price models ranged between 63% and 77% for Norway, Bergen, Trondheim, and Stavanger, whereas the explanatory power of the Oslo model was only 45%, potentially indicating that Oslo could be influenced by additional unobserved factors or speculative behaviors not captured by our models. This lower explanatory power suggests that the Oslo housing market might be subject to influences beyond the fundamental economic variables considered in our analysis to a greater extent than the other four housing markets.

Based on our analysis, we cannot determine with great certainty whether the housing prices are overvalued based on the fundamental factors investigated in our thesis. Our data and model results does, however, indicate that the current housing price trends are unsustainable in Norway, Oslo, Bergen, Trondheim, and Stavanger. Among these, Oslo shows greater signs of deviation from fundamental values than the others. The model results show that while the price development is largely explained by fundamental factors, there are other warning signs that need to be considered.

Moving forward, there will be modest new construction, as discussed in Section 8.6.5, with current building permits at their lowest issuance numbers in more than 13 years. This, alongside high housing demand in urban areas, particularly in central locations where the availability of new or vacant used homes is low, could cause the housing prices to continue their upward trajectory. In Section 4.2, we also observed that the real housing prices have decreased between approximately 6-13% across Norway, Oslo, Bergen, Trondheim, and Stavanger, which could suggest that housing prices already have undergone a small correction. Regardless, the imbalance between supply and demand, particularly in the big cities, could lead to upward pressure on prices. Furthermore, housing prices have been growing faster than inflation and the total wage income in the Norwegian economy over the last 26 years. According to literature, this rate of price growth can be considered artificially high and suggests that the price development for the housing prices we investigate is not sustainable in the long term. Consequently, to realign with fundamental factors in the long run, housing prices will likely need to decrease eventually.

References

Algieri, B. 2013. "*House Price Determinants: Fundamentals and Underlying Factors*", Comparative Economic Studies, Palgrave Macmillan: Association for Comparative Economic Studies, vol. 55(2), 315-341. Retrieved May 4, 2024, from https://www.researchgate.net/publication/263328729_House_Price_Determinants_Fundamentals_and_Underlying_Factors

Anundsen, K. Hov, M. (2023) «*Boligmarkedets problem er ikke svak etterspørsel*». Dagens Næringsliv. Retrieved February 20, 2024, from https://www.dn.no/eiendom/eiendom/bolig/boligbygging/boligmarkedets-hovedproblem-er-ikke-svak-ettersporsel/2-1-1572056

Borgersen, T. A., & Greibrokk, J. (2005). «*Boligpriser og endogen kredittrasjonering–Kredittsykluser, formueseffekter og markedsklarering*.» Norsk Økonomisk Tidsskrift, 84-102.

Brooks, C. 2019. "*Introductory Econometrics for Finance: Fourth Edition*". The ICMA Centre, Henley Business School, University of Reading. Cambridge University Press, 270-361.

Gjedrem, S. (Central Bank Governor). (2001). "*Is the Financial System Stable?*" Norges Bank. Retrieved March 5, 2024, from https://norges-bank.brage.unit.no/norges-bank-xmlui/bitstream/handle/11250/2571287/Is%20the%20financial%20system%20stable.pdf?sequence=1

Eiendom Norge (2024), «*Eiendomsmeglerforetakenes Forening (EFF) skifter navn*», Eiendomnorge.no, Retrieved May 2, 2024, from https://eiendomnorge.no/nyheter/eiendomsmeglerforetakenes-forening-eff-skifter-navn-article971-919.html#:~:text=P%C3%A5%20generalforsamlingen%20i%20Eiendomsmeglerforetakenes%20Forening,skifter%20navn%20til%20Eiendom%20Norge

Eiendom Norge. (2024). «*Statbank – Housing Price Index 2003 – 2023*». Retrieved April 18, 2024, from https://eiendomnorge.no/boligprisstatistikk/statistikkbank/

Eiendom Norge. (2024). «*Sterk oppgang i boligprisene i Mars*». Retrieved April 20, 2024, from https://eiendomnorge.no/nyheter/sterk-oppgang-i-boligprisene-i-mars-article2657-919.html

Eitrheim, Ø. Klovland, J.T., Qvigstad, J.F. (2022). «*Historical Monetary and Financial Statistics for Norway*". Occasional Papers no. 57. Norges Bank. Retrieved March 17, 2024, from https://www.norges-bank.no/contentassets/040cc5261ff74feca3af4b7b0ea46dc4/occ-papers-57-2022-hmfs.pdf?v=28042023154520

Engle, R. and Granger, C. (1987) "*Cointegration and Error Correction: Representation*", Estimation and Testing. Econometrica, 55, 251-276. Retrieved May 2, 2024, from http://dx.doi.org/10.2307/1913236

Erlandsen, Ø. Eitrheim, S. (2004), "*House prices in Norway 1819–1989*". Norges Bank. Retrieved April 1, 2024, from https://www.norges-bank.no/globalassets/upload/hms/pdf/hmsi_chapter9.pdf?v=09032017122524

Finans Norge & Verian Group. (2024). «*Forventningsbarometeret*». Finans Norge. Retrieved May 10, 2024, from https://www.finansnorge.no/tema/statistikk-og-analyse/forventningsbarometeret/siste-kvartalstall/

Fredriksen, H (2007), «*En kritisk gjennomgang av Jacobsen og Naug sin modell for hva som driver boligprisene*», NHH. Retrieved March 30, 2024, from https://openaccess.nhh.no/nhh-xmlui/handle/11250/167773

Grytten, O. (2009). «*Boligboble?*». *Magma*, *12*(5). Retrieved April 25, 2024, from https://old.magma.no/boligboble

Jacobsen, D.H. Naug, B. (2004). «*Hva driver boligprisene?»* Norges Bank. Retrieved February 10, 2024, from https://www.norges-bank.no/globalassets/upload/publikasjoner/penger_og_kreditt/2004-04/jacobsen.pdf?v=09032017122252#:~:text=En%20økning%20i%20boligprisene%20vil,enn%20sist%20de%20ble%20omsatt.

Johansen, S. (1988) "*Statistical Analysis of Cointegrating Vectors*". Journal of Economic Dynamics and Control, 12, 231-254. Retrieved May 2, 2024, from http://dx.doi.org/10.1016/0165-1889(88)90041-3

LSEG (2024), "*Olav Thon Eiendomselskap ASA*» LSEG database, Retrieved May 1, 2024.

LSEG (2024), "*S&P 500, Total Return Index* » LSEG database, Retrieved May 1, 2024.

LSEG (2024), «*Oslo Exchange Benchmark, Total Return Index*», LSEG database, Retrieved May 1, 2024.

Moe, T. Solheim, J. and Valde, B. "*The Norwegian banking crisis*", Occasional Papers no. 33, Oslo 2004. Norges Bank. Retrieved March 15, 2024, from https://www.norges-bank.no/contentassets/ed5dd397dce345338046a22c7e07f959/hele_heftet.pdf?v=09032017122240

NAV. (2024). «*Historisk Statistikk om Arbeidsmarkedet*». NAV. Retrieved April 26, 2024, from https://www.nav.no/no/nav-og-samfunn/statistikk/arbeidssokere-og-stillinger-statistikk/historisk-statistikk

NEF (2023) «*Fallende andel sekundærboliger – Økende etterspørsel etter leieboliger*» NEF.no. Retrieved May 16, 2024, from https://nef.no/statistikk/fallende-andel-sekundaerboliger-okende-ettersporsel-etter-leieboliger/

Norges Bank (2024), "*Styringsrenten*", Norges-bank.no, Retrieved February 8, 2024, from https://www.norges-bank.no/tema/pengepolitikk/Styringsrenten/

OECD (2024), "*Household debt (indicator)". OECD.* Retrieved May 5, 2024, from https://data.oecd.org/hha/household-debt.htm

OECD. (2024). "*OECD better life index – Norway*". OECD. Retrieved May 5, 2024, from https://www.oecdbetterlifeindex.org/countries/norway/

Oust, A. (2024) "*Boligleie er historisk ulønnsomt*». NRK.no. Retrieved March 28, 2024, from https://www.nrk.no/norge/boligutleie-er-historisk-ulonnsomt-1.16820555

Poterba, J, (1984) «*Tax Subsidies to Owner-Occupied Housing: An Asset-Market Approach",* The Quarterly Journal of Economics. Retrieved Jan 10, 2024, from https://doi.org/10.2307/1883123

Regjeringen (2024), «*Utlånsforskriften*», Regjeringen.no, Retrieved June 2, 2024, from https://www.regjeringen.no/no/tema/okonomi-og-budsjett/finansmarkedene/utlansforskriften/id2950571/

Sande, S. (2024). «*Den Norske Boligprismodellen*». Eiendom Norge. Retrieved February 12, 2024, from https://eiendomnorge.no/om-oss/visjon-og-verdier/den-norske-boligmodellen

Sørvol, J. (2011) «*Norsk boligpolitikk i forandring 1970-2010*». Nova 2011. Retrieved March 20, 2024, from https://biblioteket.husbanken.no/arkiv/dok/Komp/Norsk%20boligpolitikk%20i%20forandring.pdf

Statistics Norway (SSB). (2024), "*Building statistics*", SSB.no, retrieved April 10, 2024, from https://www.ssb.no/en/statbank/table/03723

Statistics Norway (SSB). (2024), "*Domestic loan debt, by borrower, lender and currency (NOK million) 1987M12-2024M04*". SSB.no, Retrieved April 12, 2024, from https://www.ssb.no/en/statbank/table/06718

Statistics Norway (SSB). (2024), "*Interest rates in banks and mortgage companies*", SSB.no, Retrieved 15.05.2025, from https://www.ssb.no/en/statbank/table/07200

Statistics Norway (SSB). (2024), "*Labour force survey*", SSB.no, retrieved April 13, 2024, from https://www.ssb.no/en/statbank/table/07458

Statistics Norway (SSB). (2024), «*National accounts*», SSB.no, Retrieved April 10, 2024, from https://www.ssb.no/en/statbank/table/09175

Statistics Norway (SSB). (2024). SSB.no. "*Consumer Price Index*". Retrieved March 1, 2024, from https://www.ssb.no/priser-og-prisindekser/konsumpriser/statistikk/konsumprisindeksen

Statistics Norway (SSB). (2024). SSB.no. "*Financial accounts*". SSB.no. Retrieved April 2, 2024, from https://www.ssb.no/en/statbank/table/09477

Statistics Norway (SSB). (2024). SSB.no. "*Housing Conditions. Tenure status – Residents*". Retrieved April 2, 2024, from https://www.ssb.no/en/statbank/table/11038

Statistics Norway (SSB). (2024). "*Interest rates in banks and mortgage companies*". SSB.no. Retrieved March 28, 2024, from https://www.ssb.no/en/statbank/table/10648

Statistics Norway (SSB). (2024). “*Financial sector accounts*”. SSB.no. Retrieved April 9, 2024, from https://www.ssb.no/en/nasjonalregnskap-og-konjunkturer/finansregnskap/statistikk/finansielle-sektorregnskaper

Stock, J. & Watson, M. (2020) “*Introduction to Econometrics Global Edition*”. Fourth Edition. Pearson.

Econ (2014). «*Eiendomsmeglerbransjens boligprisstatistikk 1985-2013*». Finn.no, Eiendomsverdi, EFF & NEF.

Tønnessen, M. (2019). *Demografiske Sykluser*. snl.no. Retrieved April 20, 2024, from https://snl.no/demografiske_sykluser

Torsvik, M.T. (1999). «*Bankkrisen*». Statistics Norway (SSB). Retrieved April 2, 2024, from: https://www.ssb.no/bank-og-finansmarked/artikler-og-publikasjoner/bankkrisen

Trading Economics, (2024), «*Norway Corporate Tax Rate*”, Tradingeconomics.com, Retrieved April 25, 2024, from https://tradingeconomics.com/norway/corporate-tax-rate#:~:text=The%20Corporate%20Tax%20Rate%20in,of%2022.00%20percent%20in%202019.

Wooldridge, J. (2019) Introductory Econometrics: A Modern Approach 7th Edition. Cengage. 367.